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Burnt Fork Dam,
Stevensville,
Montana, Ravalli
County, MT-1168

37.

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

BURNT FORK DAM
STEVENSVILLE, MONTANA
RAVALLI COUNTY
MT-1168

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PREPARED FOR:

HONORABLE THOMAS L. JUDGE
GOVERNOR, STATE OF MONTANA

SUNSET IRRIGATION DISTRICT
(OWNER AND OPERATOR)

PREPARED BY:
CH2M HILL
BELLEVUE, WASHINGTON

JULY 1980

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EXECUTIVE SUMMARY

Under contract with the Seattle District Corps of Engineers, and with representation from the Corps, the State of Montana Department of Natural Resources and Conservation, the U.S. Forest Service, and the Sunset Irrigation District, CH2M HILL inspected Burnt Fork Dam on July 17, 1979 under the authority of Public Law 92-367. The dam is located on Burnt Fork, a tributary of the Bitterroot River in Ravalli County, about 19 miles southeast of Stevensville and 16 miles east of Hamilton, Montana.

This report was compiled from information obtained during an onsite inspection, review of construction plans, and analysis of available hydrologic information. Findings were compared with engineering criteria that are currently accepted by most private and public agencies engaged in dam design, construction, and operation.

FINDINGS AND EVALUATION

Burnt Fork Dam is owned and operated by the Sunset Irrigation District. The dam and reservoir are located on public land administered by the U.S. Forest Service. Burnt Fork Reservoir is used for storage of irrigation waters. Use of National Forest Land for such purposes is through special use permits issued by the U.S. Forest Service.

The 40-foot-high earth dam, designed by the U.S. Soil Conservation Service, impounds 1,320 acre-feet of water at assumed top of dam, elevation 7261.8 feet National Geodetic Vertical Datum (NGVD). All elevations used in this report are based on assumed elevation 7255.5 for the top of the principal spillway roller gate; this is elevation 95.5 on the construction plans. On the basis of criteria in U.S. Army Corps of Engineers' Recommended Guidelines for Safety Inspection of Dams (Ref. 1), the project is intermediate in size. The dam is located such that its failure could endanger many lives. However, no dam breach analysis or routing of a dam breach flood was made for the downstream area. The conclusions on probable damage are based on a brief field visit and engineering judgment.

The project is classified as having a high (Category 1) downstream hazard potential. Inspection criteria (Ref. 1) recommend that the spillway design flood for an intermediate-sized project with a high downstream hazard potential be capable of safely handling 100 percent of the probable maximum flood (PMF). The PMF is the flood expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region.

An estimated thunderstorm PMF was developed for the 0.96-square-mile drainage basin during this dam safety study. The PMF resulting from the 6-hour thunderstorm has an estimated volume of 450 acre-feet and a peak flow of 8,200 c.f.s. The emergency spillway and the principal spillway have combined maximum discharge capacity of 330 c.f.s., with the reservoir at assumed top of dam, elevation 7261.8 feet NGVD. The routing of the PMF was started with the reservoir 1.9 feet below the emergency spillway crest. The routing of the full PMF indicates that the dam is just overtopped when approximately 55 percent of the total flood volume enters the reservoir. A flood with a hydrograph having ordinates corresponding to 56 percent of the PMF ordinates is just controlled by the project. The dam is constructed of materials that would quickly erode and rapidly fail when overtopped by floodwaters. Such failure could endanger many lives in the campgrounds downstream of the dam.

A visual inspection of the embankment revealed no serious cracks, irregularities, slumps, or erosion. However, because of seepage existing at the downstream toe, a non-verified phreatic surface used in design, and an existing embankment that appears to differ from the model used in the design, it is our judgment that the embankment should be considered as not conforming to the recommended guidelines regarding embankment stability until appropriate field investigations, laboratory tests, and a stability reevaluation, based on those data, is accomplished.

On the basis of the field inspection and study of hydrologic data, Burnt Fork Dam does not now conform to Corps guidelines with respect to discharge and/or storage capacities to safely handle the SDF (spillway design flood).

RECOMMENDATIONS

A downstream warning system, for use in the event of possible dam overtopping or structural failure, needs to be developed and immediately placed in operation. Inspect the entire length of outlet conduit and repair as required. Recompact and vegetate the downstream slope. At the downstream toe, in the area of the low level exit, design and install a toe drain. Periodically inspect downstream slope, toe, and abutments for changes in seepage conditions.

Conduct more detailed hydrologic and hydraulic routing studies to better determine the downstream hazard and required spillway capacity, and modify the project as studies indicate. Investigate the observed seepage, determine the phreatic surface by the installation and monitoring of piezometers. Conduct studies, including field exploration and laboratory testing of foundation and embankment soils, to evaluate embankment stability and modify the project as studies indicate. Conduct periodic inspections of the

project, at intervals not to exceed 5 years, by geotechnical engineers experienced in dam design and construction.

MONTANA
RICHARD L.
FOSTER
2646 E
REGISTERED
PROFESSIONAL ENGINEER

Richard L. Foster
Professional Engineer

PERTINENT DATA

1. General

Federal ID No.	MT-1168
Owner	Sunset Irrigation District
Operator	Sunset Irrigation District
Date Constructed	1977
Purpose	Irrigation
Location	Section 3, T6N, R18W Principal Meridian
County, State	Ravalli County, Montana
Watershed	Burnt Fork of the Bitterroot River
Downstream Hazard Potential	Category 1 (High)
USGS Quadrangle	Burnt Fork Lake

2. Reservoir

Surface Area at Spillway Crest	49 acres
Drainage Area	0.96 square miles
Storage at Emergency Spillway Crest (Elevation 7259.4 feet NGVD)	1,200 acre-feet
Storage at Dam Crest (Elevation 7261.8 feet NGVD)	1,320 acre-feet
Surcharge Storage	120 acre-feet

3. Emergency Spillway

Type	Uncontrolled, unlined chute
Bottom Width	Varies, 19 to 27 feet
Crest Elevation	7259.4 feet NGVD

Capacity with Reservoir at Dam Crest	270 c.f.s.

4. Outlet Works Principal Spillway

Conduit	30-inch-diameter reinforced concrete
Conduit Length	160 feet
Gates	Two 30- by 30-inch sluice gates Two 50-inch-wide roller gates act as principal spillway
Capacity with Reservoir at Dam Crest	
(All gates closed)	68 c.f.s.
(Sluice gates open)	140 c.f.s.

5. Dam

Type	Rolled earth
Length	560 feet
Crest Width	14 feet
Crest Elevation	7261.8 feet NGVD
Hydraulic Height (Crest to Toe)	40 feet
Upstream Slope	1 V on 3 H
Downstream Slope	1 V on 2 H

Chapter 1
BACKGROUND

1.1 INTRODUCTION

1.1.1 Authority and Scope

This report summarizes the Phase I inspection and evaluation of the Burnt Fork Dam, owned by the Sunset Irrigation District.

The National Dam Inspection Act, Public Law 92-367 dated August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to conduct safety inspections of non-Federal dams throughout the United States. Pursuant to that authority, the Chief of Engineers issued "Recommended Guidelines for Safety Inspection of Dams" in Appendix D, Volume 1 of the U.S. Army Corps of Engineers' report to the United States Congress on "National Program of Inspection of Dams" in May 1975.

The recommended guidelines were prepared with the help of engineers and scientists highly experienced in dam safety from many Federal and state agencies, professional engineering organizations and private engineering consulting firms. Consequently, the evaluation criteria presented in the guidelines represent the comprehensive consensus of the engineering community.

Where necessary, the guidelines recommend a two-phased study procedure for investigation and evaluation of existing dam conditions, so deficiencies and hazardous conditions can be readily identified and corrected. The Phase I study is:

(1) A limited investigation to assess the general safety condition of the dam.

(2) Based upon an evaluation of the available data and a visual inspection.

(3) Performed to determine if any needed emergency measures and/or if additional studies, investigations, and analyses are necessary or warranted.

(4) Not intended to include extensive explorations and analyses or to provide detailed alternative correction recommendations.

The Phase II investigation includes all additional studies necessary to evaluate the safety of the dam. Included in

Phase II, as required, should be additional visual inspections, measurements, foundation exploration and testing, material testing, hydraulic and hydrologic analyses, and structural stability analyses.

The authority for the Corps of Engineers to participate in the inspection of non-federally owned dams is limited to Phase I investigations with the exception of situations of extreme emergency. In these cases, the Corps may proceed with Phase II studies but only to the extent needed to answer serious questions relating to dam safety that cannot be answered otherwise. The two phases of investigation outlined above are intended only to evaluate project safety and do not encompass in scope the engineering required to perform design or corrective modification work. Recommendations contained in this report may be for either Phase II safety analyses or detailed design study for corrective work.

The responsibility for implementation of these Phase I recommendations rests with the dam owner and the State of Montana. It should be noted that nothing contained in the National Dam Inspection Act, and no action or failure to act under this act shall be construed (1) to create liability in the United States or its officers or employees for the recovery of damage caused by such action or failure to act or (2) to relieve an owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam.

1.1.2 Purpose

The purpose of the inspection and evaluation is to identify conditions that threaten public safety, so that they may be corrected in a timely manner by non-Federal interests.

1.1.3 Inspection

The findings and recommendations in this report are based on a brief visual inspection of the project and a detailed review of available construction plans. Inspection procedures and criteria are those established by the Recommended Guidelines for Safety Inspection of Dams (Ref. 1).

Personnel present during the inspection included:

Captain Don Warner, Corps of Engineers
Art Taylor, State of Montana Department of Natural Resources and Conservation
Alex Bailey, State of Montana Department of Natural Resources and Conservation

Ron Volden, U.S. Forest Service
Ray Thompson, U.S. Forest Service
Jim Anderson, Sunset Irrigation District
Ernie Patterson, Sunset Irrigation District

CH2M HILL personnel who participated in the July 17, 1979, field inspection and contributed to this report are:

Miles C. Bubenik, Geotechnical Engineer, Team Leader
Jerry Jacksha, Geotechnical Engineer
Loren Bottorff, Hydrologist/Hydraulics Engineer

This report has been reviewed by the Soil Conservation Service, the Sunset Irrigation District, the Forest Service, and the State of Montana Department of Natural Resources and Conservation. Their comments are enclosed in the Appendix.

1.2 DESCRIPTION OF PROJECT

1.2.1 General

Burnt Fork Dam is located on Burnt Fork, a tributary of the Bitterroot River, in Ravalli County, Montana, approximately 19 miles southeast of Stevensville and 16 miles east of Hamilton (see Plate 1 and 2). The dam and reservoir are located on public land administered by the U.S. Forest Service. Authorization for the use of National Forest Land is through special use permits. The Federal identification number for the dam is MT-1168. The U.S. Forest Service also identifies Burnt Fork Dam as a high hazard structure because of the possible loss of life if failure occurs. The 40-foot-high, 560-foot-long earth dam, completed in 1977, impounds 1,320 acre-feet at the crest, assumed elevation 7261.8 feet NGVD. All elevations used in this report are based on assumed elevation 7255.5 for the top of the principal spillway roller gate; this is elevation 95.5 on construction plans.

Based on visual reconnaissance and engineering judgment, Burnt Fork dam is located such that a sudden breach could endanger many lives in a downstream Forest Service campground, cause some flooding in the agricultural land around Stevensville, and minor flooding in Stevensville. According to information received from the U.S. Forest Service, the campground is used year-round, with heavy use from the beginning of June through Labor Day each year. The Forest Service estimates a range of 200 to 450 visitors daily during the summer months and a maximum of 35 persons in the campground at any given time. On the basis of this information, and in accordance with the recommended guidelines, the project size is intermediate and the downstream hazard potential is high.

The 49-acre reservoir is used to store water for irrigation, but it does receive some recreational use. The dam is reached after a vehicle trip of approximately 2 hours from Stevensville on a dirt road. The dam is owned and operated by the Sunset Irrigation District.

The 430-foot-long, 24-foot-wide, uncontrolled, unlined spillway chute is located in the left abutment of the dam (Plate 3 and Photo 1).

The low level outlet and the principal spillway are combined into a single structure located near the center of the dam (see Photo 2). The outlet conduit is 30-inch-diameter reinforced concrete. The flow is controlled by two 30- by 30-inch sluice gates and two 50-inch-wide roller gates.

1.2.2 Regional Geology and Seismicity

The geology and seismicity of the Burnt Fork Dam reservoir area were addressed in a memorandum by R. D. Eckerlin (Ref. 2). The following is taken from that memorandum.

Burnt Fork Dam is located in the headwaters of Burnt Fork, a tributary of the Bitterroot River in the central part of the Sapphire Mountains, within the Northern Rocky Mountains physiographic province. The Sapphire Mountains are rugged and composed mostly of sedimentary rocks belonging to the Precambrian Belt series.

A zone of major left lateral translation known as the Lewis and Clark Line, a part of the Montana Lineament, tectonically divides the Northern Rocky Mountains physiographic province into a Northern and Southern segment.

Evidence of Pleistocene alpine glaciation can be seen in the Sapphire Mountains in the form of cirques, moraines, and outwash terraces extending down the valleys. Burnt Fork Lake is situated within a glacial cirque perched on the eastern slope of Palisade Mountain.

Burnt Fork Dam lies within seismic zone 2, as noted on the Guidelines Seismic Map (Ref. 1). Within this zone moderate damage can be expected from earthquakes. The dam is adjacent to the seismically quiet Bitterroot Valley. Based on historic seismicity, little risk is expected. Studies performed by Algermissen (1976) indicate a 90 percent chance of 0.04 g acceleration being felt at this dam in a 50-year period.

1.2.3 Site Geology

Twenty preconstruction borehole logs, the deepest 38 feet, were drilled through the original dam embankment into the foundation materials. Along the existing dam centerline,

the original dam fill was about 18 feet thick at the deepest point. The foundation materials are glacial deposits up to 20 feet thick overlying the bedrock. A dam embankment profile showing the original dam and the results of the boring logs is shown on Plate 4.

Both the right (southeast) and the left (northwest) abutments appear to be founded on glacial sediments. Plate 4 shows that the bedrock is very near the surface at the left abutment. The unlined emergency spillway, located on the left abutment, exposed the glacial deposits in a hillside cut (Photo 1) and bedrock was not encountered. The low-level outlet, consisting of a 30-inch-diameter conduit beneath the embankment, is founded on the glacial sediment throughout its length. A statement in the U.S. Soil Conservation Service (SCS) design report (Ref. 2) mentioned that the principal spillway conduit would be placed on a yielding foundation that averages about 12 feet thick over the bedrock. This basically agrees with information on Plate 4.

The reservoir shoreline varies from gradual slopes near the dam to near vertical at the southern end of the reservoir where the glacial lake existed. The glacial lake was estimated to be 90 feet deep by local residents present at the inspection. Reservoir slopes did not show evidence of old or recent sliding.

1.2.4 Design and Construction History

The Burnt Fork Dam, designed by the SCS in 1977 for the Sunset Irrigation District, lies on National Forest Land and is operated under a special use permit. The dam was built in 1977 by Clark Brothers Construction. Another dam (completed about 1936) at the same site was removed by the 1977 construction. As-built drawings on file with the State of Montana and an SCS design report available as part of Ref. 2 were reviewed. The SCS also made available a geologic report, laboratory test data, and detailed design support data, as well as construction specifications. Plates 1 through 10 were developed from SCS drawings.

Chapter 2
INSPECTION AND RECORDS EVALUATION

2.1 HYDRAULICS AND STRUCTURES

2.1.1 Emergency Spillway

The emergency spillway for Burnt Fork Dam is located in natural ground of the left abutment. The spillway consists of an unlined earth and rock chute approximately 425 feet in length (Photo 1). The crest spillway width averages 24 feet, is 2.4 feet lower than the low point on the dam crest, and is located approximately 175 feet downstream of the chute entrance. The plans show the chute as a trapezoidal section with 1 V on 2 H side slopes and with a 26-foot bottom width, but field measurements showed the bottom width varying from 19 feet to 27 feet. The channel has an adverse slope of 0.01 from the chute entrance to the crest and a slope of about 0.02 from the crest to the discharge end of the chute (Plate 5).

Most of the spillway has been excavated; however, a trail dike has been constructed along portions of the right (looking downstream) side of the spillway (Plate 5). The chute discharges on the side of the hill about 30 feet above creek level. The discharge point is about 210 feet downstream of the dam axis and does not endanger the embankment safety. The spillway appeared to be in very good condition, but it has never been operated. The spillway does not appear to be subject to erosion. A log boom is located in the reservoir to protect the spillway from floating debris. A few logs have collected on the upstream side of the boom, and one log had almost passed over the boom.

The emergency spillway discharge rating was developed by assuming that critical depth occurs at the 24-foot-wide crest section near the dam axis. Backwater computations were made in the approach channel using a Manning's "n" of 0.028. The maximum discharge capacity of the spillway with the reservoir at assumed top of dam, elevation 7261.8 feet NGVD, was estimated to be 270 c.f.s. The emergency spillway rating curve is presented on Plate 6.

2.1.2 Outlet/Principal Spillway

The low level outlet works and the principal spillway for Burnt Fork Dam are combined into a single structure located near the center of the dam. A 30-inch-diameter reinforced concrete pipe extends through the embankment and a control structure is located just upstream of the dam crest. The intake structure could not be inspected because of the

reservoir level; however, the as-built plans (Plate 9) show a reinforced concrete trash rack. The 30-inch-diameter conduit extends 65 feet from the intake structure to the control structure on a slope of 0.0630. The conduit extends 95 feet from the control structure to the outlet structure on a slope of 0.04842. The outlet structure is a simple concrete headwall with a shallow riprapped basin downstream. The downstream discharge channel was riprapped and appeared to be in good condition.

The control structure consists of a wet well with four control gates (see Plate 7). The wet well contains two interior concrete walls that are perpendicular to the direction of flow. Each wall has one 30-inch-diameter opening at the bottom, controlled by a 30- by 30-inch cast-iron sluice gate at the low level outlet portion of the structure. The wall that is nearer the upstream end of the control structure extends 9.5 feet above the bottom of the structure and the downstream wall extends 16.5 feet above the bottom of the structure. Roller gates, extending the width (approximately 50 inches) of the wet well, are fitted on the downstream side of each wall. The effective height of each wall can be changed by raising or lowering the roller gate at the wall. The top of the uppermost roller gate serves as the principal spillway for the dam. The controls for all four gates are located at the top of the control structure. The gate stems are protected from the weather by pipe extending above the operating controls (Photo 2). The outlet conduit and wet well are vented by a 4-inch-diameter pipe fitted with an air release valve.

The discharge rating of the principal spillway was developed with both sluice gates closed and both roller gates all the way up. This places the top of the upstream gate at elevation 7242 feet NGVD and the top of the downstream gate at elevation 7255.5 feet NGVD. The downstream gate was assumed to function as a sharp-crested weir. The rating was developed by using the weir head/discharge relationship with a constant discharge coefficient of 3.32. Energy losses in the upstream conduit were accounted for by using a Manning's "n" of 0.011 for full conduit flow. The maximum discharge of the principal spillway, with the above conditions and with the reservoir at top of dam, elevation 7261.8 feet NGVD, was estimated to be 68 c.f.s. The principal spillway rating curve is presented on Plate 8. The rating would change if the roller gates were lowered, and thus there are an infinite number of ratings.

The discharge rating of the low level outlet was developed with both sluice gates fully open. A Manning's "n" of 0.011 was used to estimate friction losses with the conduit flowing

full. The maximum discharge capacity of the outlet works, with the reservoir at top of dam (elevation 7261.8 feet NGVD) was estimated to be 140 c.f.s.

2.1.3 Freeboard

Because the dam overtops during the probable maximum flood (PMF; see Paragraph 2.2.4), it has no freeboard. The vertical distance between the low point on the dam and the reservoir level at the time of the inspection was 5.9 feet. The spillway crest is 2.4 feet below the low point on the dam crest. The crest of the dam, as determined by survey, varies 1.3 feet over its 560-foot length. The effective fetch for wind-generated waves is about 1,000 feet and wave runup on the embankment is estimated to be less than 2 feet. Although the dam will overtop during the PMF, the vertical distance between the dam crest and the normal reservoir level is adequate to prevent overtopping the embankment by wind waves.

2.2 HYDROLOGY, CLIMATOLOGY, AND PHYSIOGRAPHY

2.2.1 General

The climate of the area is modified continental, characterized by warm summers, cold winters, and a semiarid precipitation regime. The nearest climatological station (elevation 3529 feet) is at Hamilton, about 16 miles west of Burnt Fork Dam. Mean annual precipitation at the station is 13 inches, with 35 percent falling from April through June. Mean February precipitation is 0.72 inches and mean June precipitation is 2.06 inches. Mean annual precipitation on the Burnt Fork Dam drainage basin is probably near 50 inches. Mean annual temperature at Hamilton is 45.8 degrees Fahrenheit (F). Mean January temperature at Hamilton is 24.8 degrees F and mean July temperature is 67.5 degrees F. Temperatures on the Burnt Fork Dam drainage basin may average about 15 degrees cooler than Hamilton. Occasionally, summer temperatures exceed 100 degrees F and winter temperatures dip below -40 degrees F.

The drainage basin area for Burnt Fork Dam is 0.96 square miles, is roughly rectangular in shape, and is on the west slope of the Continental Divide. Basin elevations range from 7260 feet NGVD at the dam to 8399 feet NGVD on the southern boundary of the basin. Most of the annual precipitation occurs as snow, with melt beginning in late April or early May. The basin is steep and heavily forested. The SCS design report, shown as Ref. 2, estimated the annual runoff as 1,640 acre-feet.

2.2.2 Reservoir Storage and Spillway Discharge

The reservoir has a surface area of 49 acres and a storage of 1,200 acre-feet at assumed emergency spillway crest, elevation 7259.4 feet NGVD. Approximately 120 acre-feet of surcharge storage is available in the reservoir between the emergency spillway crest and the dam crest. The emergency spillway discharge with the reservoir at the dam crest is 270 c.f.s., about 22 acre-feet per hour. The principal spillway discharge with the reservoir at the dam crest is 68 c.f.s., about 6 acre-feet per hour.

2.2.3 Estimated Probable Maximum Flood

The probable maximum flood (PMF) is the flood expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The SCS made estimates of the 100-year flood and the PMF while designing Burnt Fork Dam; the SCS refers to the PMF as the freeboard hydrograph.

The principal spillway was designed by the SCS for a flood occurring from the 100-year, high, 15-day snowmelt, combined with a 100-year, 1-day, peak snowmelt. This flood has a total volume of 768 acre-feet and a peak of 62 c.f.s. The freeboard hydrograph was used by the SCS for the design of the emergency spillway and the embankment height. The U.S. Weather Bureau's Hydrometeorological Report No. 43 (Ref. 3) was used to compute the thunderstorm probable maximum precipitation (PMP).

The SCS used Section 4, "Hydrology," of their National Engineering Handbook (Ref. 4) to obtain the freeboard hydrograph from the PMP and basin characteristics. A step-by-step procedure for development of the freeboard hydrograph is outlined in Chapter 21 of this publication. The freeboard hydrograph has a volume of 342 acre-feet and a peak flow of 1,574 c.f.s. The freeboard hydrograph routing was started with 16 c.f.s passing 1.2 feet above the principal spillway. This is 1.8 feet below the emergency spillway, as designed, and 2.7 feet below the emergency spillway, as measured in the field.

The Soil Conservation Service (SCS) describes the procedure they followed in developing the design flood in their letter of April 28, 1980, in the Appendix.

An independent estimate of the PMF was made for this dam safety study. Procedures available for the area west of the Continental Divide allow for development of a PMP from a thunderstorm or a general storm. Because of the Burnt Fork Dam drainage basin size, a thunderstorm was believed to

cause the most critical flood. The procedures contained in Hydrometeorological Report No. 43 (Ref. 3) and the Weather Bureau's 1967 memo (Ref. 5) were used to compute the thunderstorm PMP. The memorandum allows for some reduction of the PMP that was not originally contained in Report No. 43.

The July or August thunderstorm PMP produces 7.5 inches in 1 hour and 9.2 inches in 6 hours. Because of the high intensity rainfall and the possibility of near saturated soil conditions from thunderstorms on preceding days, a constant 0.15-inch-per-hour loss was assumed during the thunderstorm PMP. A base flow of 15 c.f.s. was used for the entire flood. A triangular unit hydrograph for a 5-minute rainfall duration was developed for the 0.96-square-mile drainage basin by procedures outlined in Design of Small Dams (Ref. 6). A curvilinear fit of the triangular unit hydrograph was used. The PMP was applied to the unit hydrograph by means of the computer program, HEC-1 (Ref. 7). This estimate of the PMP produced a flood with a peak flow of 8,200 c.f.s. and a volume of 450 acre-feet.

2.2.4 Flood Routing

Since it is possible for major storms to occur a few days prior to the PMF, a 100-year storm with a duration of 6 hours was routed through the reservoir beginning near the principal spillway level. The routing was continued for 18 hours after the end of the storm; the principal spillway was able to lower the reservoir to 1.9 feet below the emergency spillway. Routing of the PMF was started at this level.

Routing studies indicate that:

a. During the full PMF the dam would be overtopped when approximately 55 percent of the flood volume enters the reservoir.

b. Routings were made of lesser hypothetical floods than the PMF to determine the magnitude of floods the dam can contain. The hypothetical hydrographs are obtained by applying percentages to the PMF ordinates. A flood with a hydrograph having ordinates corresponding to 56 percent PMF ordinates is just controlled by the project. Larger floods would overtop the dam.

The percent of overtopping is very sensitive to the reservoir level at the start of the storm. One foot of surcharge storage will handle over 10 percent of the PMF. Also, the PMF, as presented in this report, may not be the most critical flood for this basin. A June thunderstorm PMP, combined with snowmelt, may produce a more critical PMF causing the dam to be overtopped at a lower percentage.

2.3 GEOTECHNICAL EVALUATION

2.3.1 Dam

The 40-foot-high earthfill dam is 540 feet long and has a crest width of 14 feet at elevation 7261.8 feet NGVD, which corresponds to elevation 101.5 feet from assumed data used in the construction drawings. The upstream slope is 1 V on 3 H and the downstream slope is 1 V on 2 H. Plate 9 shows a homogeneous earth section; however, the SCS design report (Ref. 2) states that specifications required raking of oversized material to the outer 10 feet of the upstream and downstream embankment slopes. SCS construction records show that the 10-foot upstream and downstream rock zones were deleted. A cutoff trench was excavated under the upstream portion of the embankment.

The as-built plans show that the dam embankment does not incorporate an internal drainage system.

SCS specifications require that embankment materials be placed in 12-inch horizontal lifts and compacted with a sheep's foot roller.

Embankment materials were obtained from spillway and cutoff excavations as well as borrow pits located along the right side of the reservoir near the damsite. Written information (Ref. 2) and onsite interviews indicated that the original 18-foot-high dam was completely removed from the present damsite, and that its fill material was not used in the present dam because of high organic material content. However, the embankment center-line profile (Plate 4) shows that some of the original dam at the left abutment was left in place.

Our visual inspection on July 17, 1979, indicated that the surficial embankment material is a mixture of earth and rockfill containing approximately 40 to 50 percent fine sand and silt. The downstream slope had no vegetative cover (Photo 3). The upstream slope was adequately protected with an 18-inch, minimum thickness layer of 3 feet (and smaller) in diameter riprap, placed directly on the embankment surface. No filter was installed; instead, specified larger rock and gravel raked to the slope edge during construction were to provide the necessary filter. Along the crest at the downstream edge, some minor cracking was observed that we believe is caused by very shallow sloughing of loosely compacted surface materials. This condition does not affect embankment stability, but it does indicate a need for additional surface compaction and seeding to protect the slopes. No significant erosion, irregularities, slumps, or cracks were present on the dam crest or slopes.

As-built drawings indicate that the 30-inch outlet conduit is not founded in rock. The as-built plans show that the reinforced concrete bell and spigot pipe rests on a concrete cradle throughout the entire section. Eight concrete cutoff collars, uniformly spaced, are shown under the embankment section.

2.3.2 Foundation Conditions, Seepage, and Drainage

Foundation conditions are described in the preceding paragraph and in paragraph 1.2.3, Site Geology. Boring logs show glacial sediments 30 feet deep under most of the embankment. At the right abutment, boring logs were shallow, and the bedrock surface was not defined.

Before construction of the embankment cutoff trench, information indicates that most of the original dam fill was removed; the material was wasted downstream of the dam. The cutoff trench under the entire embankment was excavated into the glacial sediment to an average depth of 10 feet. Plate 4, developed from "as-built" plans, shows that bedrock may have been encountered near the cutoff base at Station 15+30. The procedure used to backfill the cutoff trench is unknown.

A detailed description of the foundation preparation is not available; however, the as-built plans show that some excavation was done under the entire embankment section. Plate 4 is a copy of an "as-built" drawing that shows the "foundation excavation line" beneath the dam embankment and cutoff.

During the inspection, seepage was observed at the downstream toe on both sides of the low level outlet (Photos 4 and 5). Total seepage flow was about 8 to 10 gpm and the water appeared to be clear. Some erosion had occurred in the fill material from the seepage. In a 1978 final construction report (Ref. 2), the following description and cause of this seepage is noted:

> "Seepage was occurring 10 feet to the left of the outlet pipe and approximately at the same height. Flows were emerging at about 5 gallons per minute. The Soil Conservation Service indicated that at the time the outlet pipe was installed, spring flows were originating approximately 20 feet upstream from the downstream toe of the dam. This should be accurately monitored on a regular basis. A toe drain will have to be installed in 1979 if flow continues at the present rate."

Near the right abutment, seepage was discharging on the disposal area downstream of the dam (Photo 6). Underseepage near the left abutment contact was observed as a wet surface area. The above-described abutment seepage was also noted

in the Forest Service final construction inspection report (Ref. 2) as follows:

> "Seepage was occurring along the right abutment for a length of about 50 feet, starting at a point 20 feet below top of dam and about 10 feet in width. Since this was occurring in an area where large amounts of saturated waste from the original dam had been spread, it was difficult to make an accurate evaluation as to the origin of the seepage. The SCS indicated they felt the seepage was from the waste material. An inspection of this area should be made in September to verify the condition.
>
> Minor seepage was also occurring on both sides of stream below toe of dam above flow measuring device. This does not indicate a problem area."

The dam embankment contains no internal drains or piezometers.

2.3.3 Stability

Stability information supplied by the SCS, including results of analyses, is contained in the appendix of Reference 2 and is summarized in Plate 10. The embankment stability model used an assumed water level surface (phreatic surface) in the embankment that was used in the analysis. Available data does not indicate how the unit weight and strength parameters were determined. The following SCS comments on stability design methods are quoted:

> "The embankment was designed to be stable without installing drainage measures, due to the unavailability of suitable drain materials at the site, and the remote location of the project."

> "In the stability analysis the outer 10 feet of the embankment was given slightly greater strength values, due to the specification requiring raking the oversized material into this area of the fill. This area of oversized fill will provide a bedding under the upstream face riprap, and a rock shell on the downstream slope. A more detailed description of this topic can be found in the support file."

During the July 17, 1979, field inspection, seepage was observed at the downstream embankment toe and on the right and left abutments. A moist area also existed on the downstream slope of the embankment on the left side. This suggests that the phreatic surface in the downstream embankment may have been well above the toe, when the reservoir pool was 5.9 feet below dam crest and the pool had been at this elevation only a short time. Also, the brief field

inspection showed the 10-foot zones on the outer edge of the embankment slopes are similar, from a strength standpoint, to the remaining embankment in that the materials contained a high percentage of fines.

Additionally, in our judgment, the unit weight and strength assigned these materials are too high (Plate 10). As an example, the unit weight of riprap should be about 125 pounds per cubic foot, not 140. The unit weight of the ML (silt) foundation soil, saturated, should be about 125 pounds per cubic foot, not 136, and friction value is probably about 31 degrees, not 36. The unit weight and strength of the SM (silty sand) and SM with oversize is also too high. The unit weight of the SM, saturated, should also be about 125 pounds per cubic foot, and the strength about 31 degrees. The cohesion should be disregarded. With respect to the infinite slope analysis shown on Plate 10, it is not applicable to mass embankment stability, but only indicative of stability of material on the outer slopes. As the weak material appears to be the ML foundation soil, analysis with failure arcs through these materials is essential.

As the dam does not have an interior drain that functions to lower the phreatic surface in the embankment, and as materials in the embankment and foundation take on the characteristics of fine-grained silts, it is our judgment that Burnt Fork Dam may not conform to the recommended guidelines with respect to embankment stability.

2.4 PROJECT OPERATION AND MAINTENANCE

The facility is owned and operated by the Sunset Irrigation District. Information on operation and maintenance was obtained from the Operation and Maintenance Plan and from a discussion with Mr. Jim Anderson, president of the Sunset Irrigation District.

2.4.1 Dam

The dam is visited as soon as possible after spring snowmelt. Visits are made about once a week during the irrigation season. Vehicular travel to the dam takes about 2 hours by dirt road from Stevensville.

The operation and maintenance plan requires inspection of the dam after a flood; service of gates as recommended by the supplier; removal of logs and other debris that may affect emergency spillway capacity; reseeding of disturbed areas; inspection of trash rack on outlet; checking the log boom to ensure proper protection is provided; observation of the downstream toe of the dam for any wet areas; checking the upstream slope and outlet channel rock riprap; checking the concrete pipe, gates, stems, and hoists; and ensuring that the gate on the access road remains locked so vehicle

traffic will not disturb emergency spillway and embankment slopes. The plan does not state the frequency of this maintenance.

The dam is very new and does not yet show areas requiring maintenance. A small amount of debris was observed along the upstream face of the dam. The downstream face of the dam did not yet show evidence of vegetation. The Forest Service conducts inspections of the facility at 2-year intervals and makes recommendations for maintenance and repairs at that time. The U.S. Forest Service special use permit calls for inspection of Burnt Fork Dam by a qualified engineer as follows:

1. Every year for the first 3 years from date of final inspection.

2. At least once every 5 years thereafter, or as directed by the forest supervisor.

3. After every major flood or unusually heavy runoff.

Also, the Irrigation District must revise the operation and maintenance plan annually, as needed, by May 1.

2.4.2 Reservoir

Water from Burnt Fork Lake is used for irrigation and Mr. Anderson serves as the gate operator. The water rights of Burnt Fork Dam drainage basin have been adjudicated, and the court decision requires passage of all inflow when prior water rights preclude storage. One of the roller gates in the control structure is set to correspond to the reservoir level when additional storage is not allowed. If the downstream roller gate is set to reservoir level, reservoir outflows spill and enter the downstream conduit. If the upstream roller gate is set to reservoir level, the downstream sluice gate must be opened to pass the flows to the conduit.

When one of the roller gates is set to reservoir level, the reservoir inflow equals reservoir outflow except for small variations caused by changes in surcharge storage. Normally, the outlet is opened about July 15 and closed about October 15 to November 15. Releases during this period are for the needs of the Sunset Irrigation District and for the downstream water rights (normally about 10 c.f.s., combined). The roller gates are lowered to the reservoir level when the Sunset Irrigation District stops irrigation in the fall. The gates remain in this position, with reservoir inflow equaling reservoir outflow, until late fall when the roller gates can be raised and storage can resume. The reservoir is usually filled by spring snowmelt.

2.4.3 Warning System

There is no formal warning plan for use in the event of impending dam failure.

Chapter 3
FINDINGS AND RECOMMENDATIONS

3.1 FINDINGS

Visual inspection of the dam, supplemented by analysis of the project in terms of the recommended guidelines performance standards, resulted in the following findings.

3.1.1 Size, Hazard Classification and Safety Evaluation

The 40-foot-high Burnt Fork Dam impounds 1,320 acre-feet of water with the reservoir at the crest of the dam. In accordance with inspection guidelines, Burnt Fork Dam is intermediate in size and, based on our visual inspection and judgment, has a high downstream hazard potential. Therefore, the guidelines' recommended spillway design flood (SDF) for this project is 100 percent of the PMF. Based on reconnaissance level investigations, the project can safely control only 55 percent of the PMF. Because the project is incapable of controlling the PMF without overtopping and causing the dam to fail, Burnt Fork Dam does not meet inspection guidelines.

3.1.2 Embankment Dam

A visual inspection of Burnt Fork Dam revealed no serious longitudinal or transverse cracks, and no serious embankment, abutment contact, or toe erosion. Seepage was observed at the downstream toe near the outlet conduit exit and at the right abutment. Moist areas on the ground surface were observed at the left abutment contact and on the embankment slope above the contact. These may be caused by underseepage.

The upstream and downstream slopes were uniform with no serious irregularities or slumps. The downstream slope at the dam crest has experienced minor slough caused by loosely compacted surface materials and lack of vegetation cover on the downstream slope. Riprap on the upstream slope adequately protects against erosion, and the normal freeboard (2.4 feet) is adequate to prevent wind-generated waves from overtopping the dam crest.

A stability analysis of the dam embankment was conducted by the Soil Conservation Service. The assigned unit weights and strength values given to materials in the various zones in the embankment (shown on Plate 10) are unusually high for those materials. The outer zones of the embankment, as indicated on Plate 10, apparently do not exist; materials in the embankment take on the characterstics of fine-grained soils; and the dam embankment has no form of interior drainage (evidenced by seepage at the downstream toe); therefore,

it is our judgment that embankment stability may not conform to the recommended guidelines.

3.1.3 Spillway and Reservoir Capacity

The reservoir has a surface area of about 49 acres and a storage of 1,200 acre-feet at assumed emergency spillway crest, elevation 7259.4 feet NGVD. Approximately 120 acre-feet of surcharge storage is available in the reservoir between the emergency spillway crest and the dam crest. Approximately 310 acre-feet of surcharge storage is available in the reservoir between the principal spillway crest and the dam crest. The combined discharge of the principal and emergency spillways, with the reservoir at the dam crest, is 330 c.f.s.

3.1.4 Outlet/Principal Spillway

The outlet works and principal spillway are combined into a single structure. The intake structure could not be inspected during the site visit because of the reservoir level, and the outlet conduit could not be inspected because of discharge. The gate stems are well protected from the weather. The outlet/principal spillway appeared to be in good condition.

3.1.5 Operation and Maintenance

The U.S. Forest Service conducts inspections of the facility and makes appropriate recommendations for maintenance and repairs at 2-year intervals. The Sunset Irrigation District is responsible for operation and maintenance. The dam is visited as soon as allowed by spring snowmelt. Visits are made about once a week during irrigation season. Vehicular travel to the dam takes about 2 hours by dirt road from Stevensville. The dam is new and does not yet show areas requiring maintenance. A small amount of debris was observed along the upstream face and the downstream face of the dam did not yet show evidence of vegetation.

There is an operation and maintenance plan (updated annually) for the dam, but it does not state the frequency of maintenance.

Water from the reservoir is used as needed for irrigation. The water rights of Burnt Fork Dam drainage basin have been adjudicated and the court decision requires passage of all inflow when prior water rights preclude storage. The roller gates can be set to pass reservoir inflow when irrigation releases are stopped in the fall. The gates remain in this position until late fall when the roller gates are raised and storage can resume. There is no formal warning plan for use in the event of impending dam failure.

3.2 RECOMMENDATIONS

The findings suggest that high priority be given the following recommendations:

1. Immediately develop, implement, and periodically test an emergency warning plan for use in the event of impending dam overtopping or structural failure.

2. Inspect the entire length of outlet conduit and repair as required.

3. Grade, recompact, and vegetate the downstream face of dam.

4. Seepage at the downstream toe in the area of the outlet works requires the installation of a weighted filter system to protect embankment and foundation materials from erosion.

5. Monitor downstream slope, toe, and abutments for any changes in seepage conditions.

6. Conduct more detailed hydrologic and hydraulic routing studies to better determine the downstream hazard and required spillway capacity and modify the project as studies indicate.

7. Conduct a detailed stability analysis using the phreatic surface data obtained by installing and monitoring piezometers; conduct laboratory tests to determine soil parameters in the analyses. Obtain undisturbed samples for test purposes. This work must be accomplished by an experienced geotechnical engineer(s). Modify the embankment as required to conform with inspection guidelines.

9. Conduct inspections of Burnt Fork Dam at least every 5 years by geotechnical engineers experienced in earth dam design and construction. However, new dams such as Burnt Fork should be inspected more frequently in the first several years after construction.

   Prior to implementing any report recommendations, the owner is urged to contact the Montana DNR&C.

REFERENCES

1. U.S. Army Corps of Engineers, Office of the Chief of Engineers Report to the U.S. Congress, National Program of Inspection of Dams, Vol. 1, Appendix D, "Recommended Guidelines for Safety Inspection of Dams," Washington, D.C., Department of the Army, May 1975.

2. U.S. Forest Service, Background and Support Data, Burnt Fork Dam, 1978.

3. U.S. Weather Bureau, Hydrometeorological Report No. 43, "Probable Maximum Precipitation, Northwest States," Washington, D.C., 1966.

4. U.S. Soil Conservation Service, "National Engineering Handbook, Section 4 - Hydrology."

5. Hydrometeorological Branch, U.S. Weather Bureau Office of Hydrology, "Memorandum: Probable Maximum Thunderstorm Rain for the Columbia River Basin East of the Cascade Ridge," September 20, 1967.

6. U.S. Bureau of Reclamation, "Design of Small Dams," 2nd Edition, 1974.

7. U.S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-1 Flood Hydrograph Package, Davis, California, 1973.

APPENDIX

DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
WATER RESOURCES DIVISION

THOMAS L. JUDGE, GOVERNOR
32 SOUTH EWING

STATE OF MONTANA

(406) 449-2872
HELENA, MONTANA 59601

March 6, 1980

Department of the Army
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, Washington 98124

Attn: Ralph Morrison

Re: CH$_2$M Hill Dam Safety Inspection report on Burnt Fork
Dam (MT-1168).

Dear Ralph:

We have reviewed the above referenced final draft report. We concur with the findings and recommendations and feel the report satisfies the criteria for the Phase I report. Minor editorial comments have been discussed with your staff and we understand these will be incorporated in the final report.

Thank you for this opportunity to review and comment on the final draft report on Burnt Fork Dam.

Sincerely,

Richard L Bondy

Richard L. Bondy, P.E.
Chief, Engineering Bureau
(406) 449-2864

RB:AT:mb

"AN EQUAL OPPORTUNITY EMPLOYER"

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
FEDERAL BUILDING MISSOULA, MONTANA 59801

(7530)
APR 7 1980

Mr. Sidney Knutson, P.E.
Seattle District Corps of Engrs.
P. O. Box C-3755
Seattle, Washington 98124

Dear Mr. Knutson:

As requested, we have reviewed the final draft report for the Phase I inspection of Burnt Fork Dam.

As with all other previous reports from your office, we disagree with the conclusions as to the "safe" or "unsafe" condition of a dam, based on one brief field visit and the computer application of extremely conservative hydrologic parameters.

The hydrologic study done by the Soil Conservation Service for Burnt Fork Dam was based on known hydrologic and climatological conditions for the drainage area and stands unquestioned by this office.

R. W. LARSE
Regional Engineer

United States Department of Agriculture

Soil
Conservation
Service

P.O. Box 970
Bozeman, MT
59715

April 28, 1980

Mr. Sidney Knutson, P.E.
Assistant Chief
Engineering Division
Seattle District Corps of Engineers
P.O. Box C-3755
Seattle, WA 98124

Dear Mr. Knutson:

We appreciate the opportunity to review and comment on the final draft report of Burnt Fork Dam Project, Montana. You are aware that our engineering staff is providing technical data to engineering firms making inspections. In regard to Burnt Fork, on March 12, 1980, we presented, by letter to Mr. Bubenik, CH_2M, pertinent information. We were of the opinion that the information would be used and a revised final draft report would be issued. Evidently this has not happened, and we would like to be on record with the following comments regarding the final report.

1) Page 8, line 10. Drill logs show that water was encountered in only Hole #4.

2) Page 9, line 13. This sentence leaves the impression that the old dam was not removed. Our construction job diary, page 19, shows that the old dam was removed.

3) Page 12, line 1. Sheet 9 of "As built" plans shows the "pair of parallel walls fitted with a trash rack" is a monolithic reinforced concrete structure consisting of a floor, cutoff walls, head wall, side walls and trash rack.

4) Pages 16, 17 and 18. The discussion of hydrology is not consistent with data in our case file. In summary, our data shows:

> "The Forest Service determined that the hazard classification for the Burnt Fork Dam was high (SCS would have classified as Class B). The Dam was then planned under Class (C) criteria of Engineering Memorandum -27 and Technical Release No. 60. Two Freeboard Hydrographs (FBH) were developed for the site. The July-August PMP, 6 hr. thunderstorm was 10.8 inches. The corresponding FBH was routed beginning at the maximum principal spillway with crest elevation of 95.5 feet with zero base flow. The July-August PMP was estimated to occur with antecedent moisture condition, AMC II, with no snowmelt. These conditions were assumed to be reasonable for this time of year. The May 15-June 15 PMP, 6 hr. thunderstorm was 8.6 inches. The corresponding FBH was routed, beginning at elevation 96.7 feet, 1.2 feet above the maximum

> principal spillway crest elevation with a 16 cfs snowmelt baseflow. The May 15-June 15 PMP was selected to represent maximum condition of rainfall with snowmelt. It was estimated to occur with AMC III, saturated soils, during average annual peak snowmelt conditions. The May 15-June 15 FBH developed maximum stage in the reservoir. The Burnt Fork Dam was designed for the above hydrology which exceeds present SCS and Forest Service criteria. The "As Built" plans show that the spillways were constructed as planned and designed."

In view of the above case data information, the final report should be presented with consideration of this information. In addition, the draft report shows a PMF of 8,200 cfs using an 8 inch rainfall in one hour. A question must be raised on the physical capabilities of this watershed to yield such a runoff in one hour. Recommendation #6 calls for additional hydrology studies. It is our opinion that a detailed hydrology study has been made and it shows that the PMF requirement is met.

5) Page 20, line 4. The material was placed in 12-inch lifts, rocks removed and compaction made with a CAT 842B sheepsfoot.

6) Page 20, line 15. Material on left abutment was determined to be original in place rather than old dam material.

7) Page 22, line 8. The construction job diary, page 18, gives details of cutoff trench construction.

8) Page 22, line 12. All of the old dam was removed.

9) Pages 24, 25 and 30. The discussion on stability of embankment indicates inconsistency between construction and design. We agree that the downstream rock facing was not installed. However, with a plot of the phreatic line for stability, geology, and lab reports and design notes available, an analysis of this data by CH$_2$M may give sufficient knowledge and recommendation #7 may not be required.

Van K Haderlie

Van K Haderlie
State Conservationist

cc:
Stan Hobson, WTSC, SCS, Portland
Charles Walter, Area Conservationist, SCS, Missoula
Ernest Busek, District Conservationist, SCS, Hamilton

In the preceding SCS letter, the page numbers referred to have changed in the final report. The correct page numbers for the comments listed are now:

1) page 5
2) page 5
3) page 7
4) pages 9, 10
5) page 11
6) page 11
7) page 12
8) page 12
9) pages 13, 14

Sunset Irrigation District
STEVENSVILLE, MONT.
59870

April 14, 1980

Sidney Knutson, P. E.
Asst. Chief, Engineering Division
Seattle District, Corps of Engineers
P. O. Box C 3755
Seattle, Washington 98124

Dear Sirs:

After reviewing your Final Draft of the inspection of the Burnt Fork Dam, we find it totally unrealistic and unacceptable. It seems to be a simple case of Bureaucrats covering themselves at our expense. Therefore, we plan to put together all of the information available and turn it over to our Congressional delegates in Washington, D. C.

Yours very truly,

SUNSET IRRIGATION DISTRICT

Jim Anderson, President

j

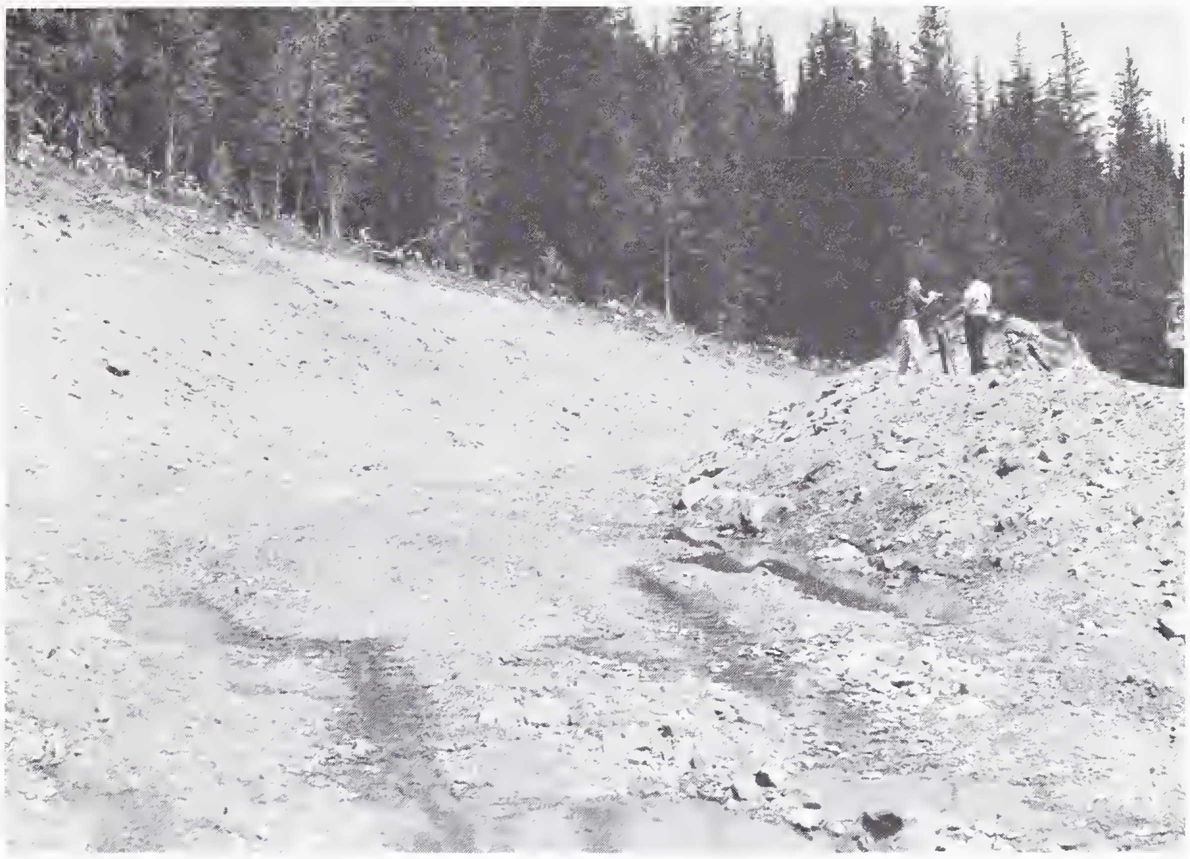


PHOTO 1 Emergency Spillway Chute (looking downstream)

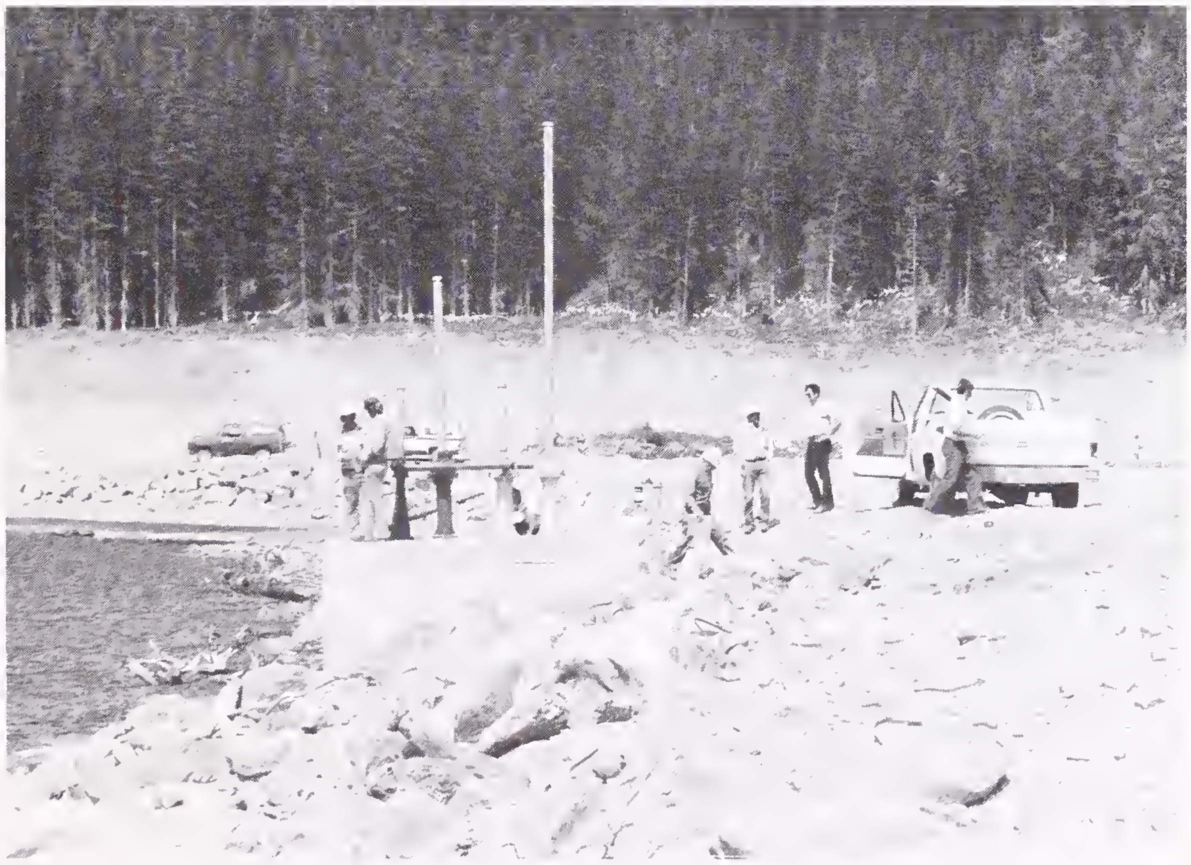


PHOTO 2 Outlet Works Gate Control

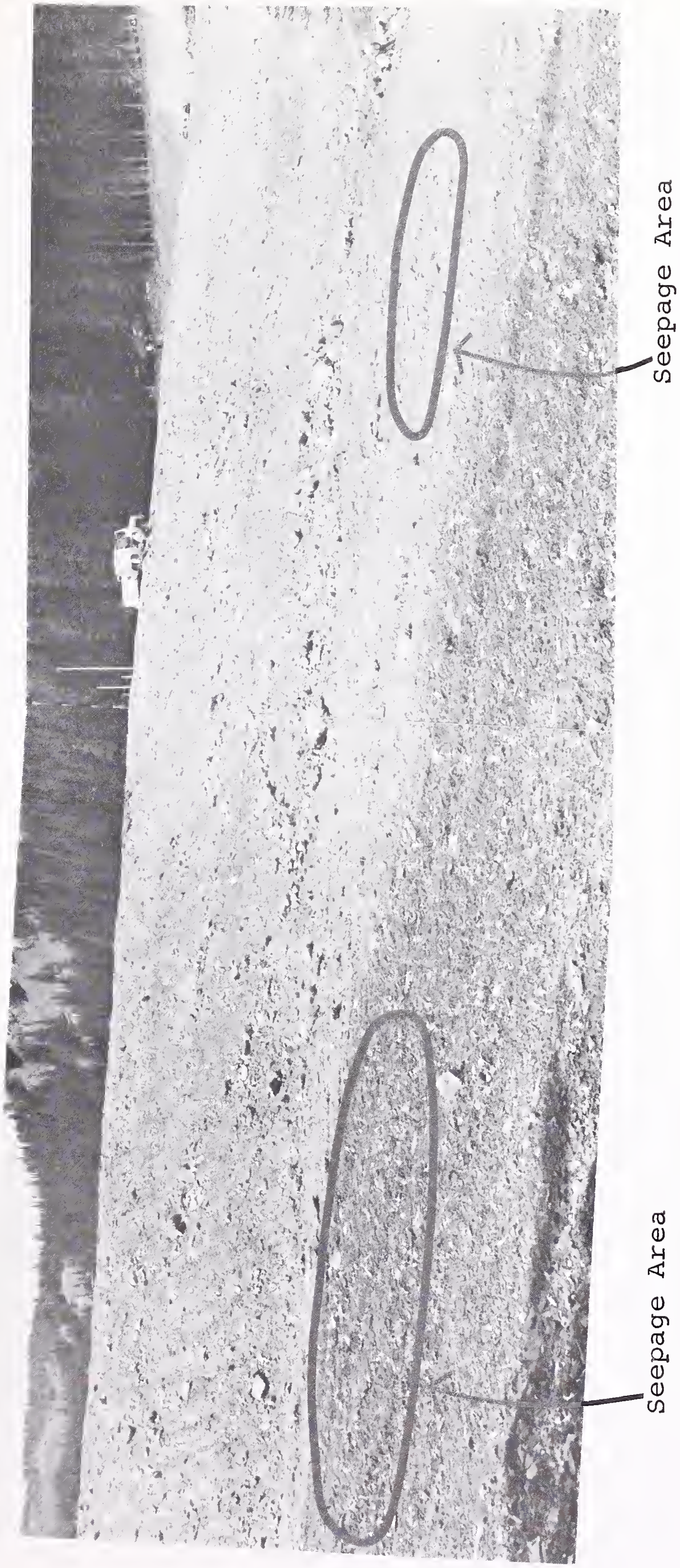
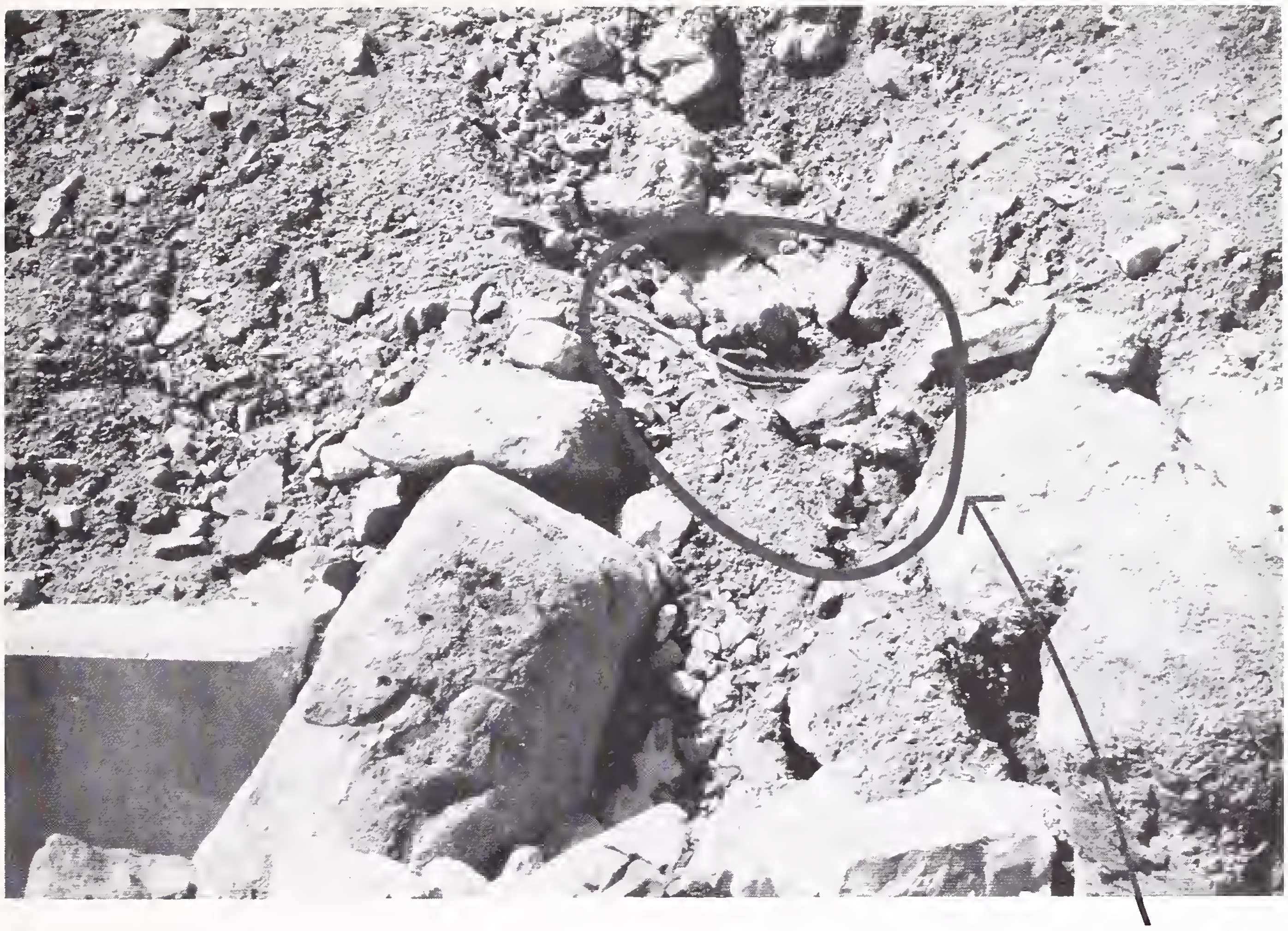
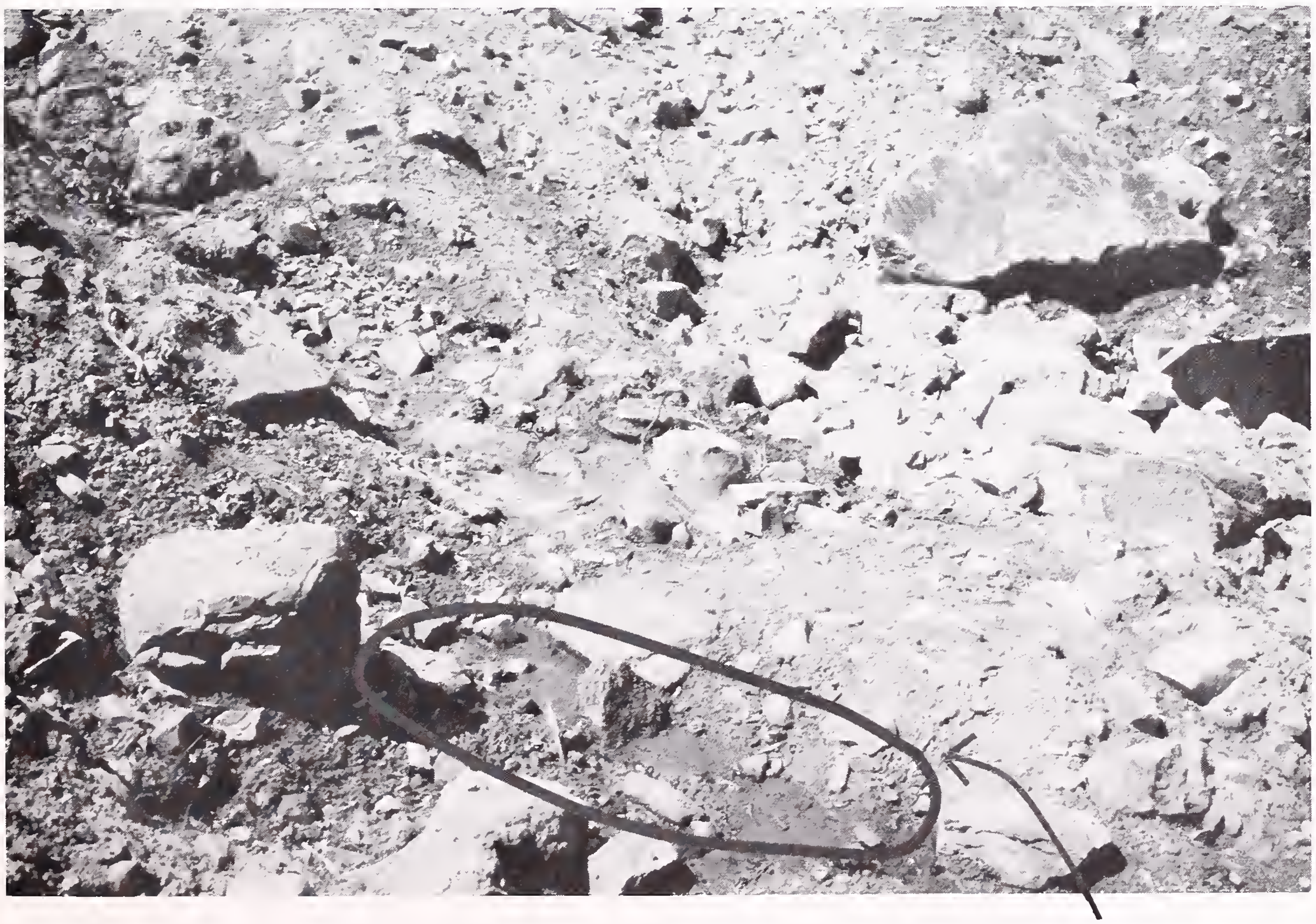


PHOTO 3 Embankment Downstream Slope



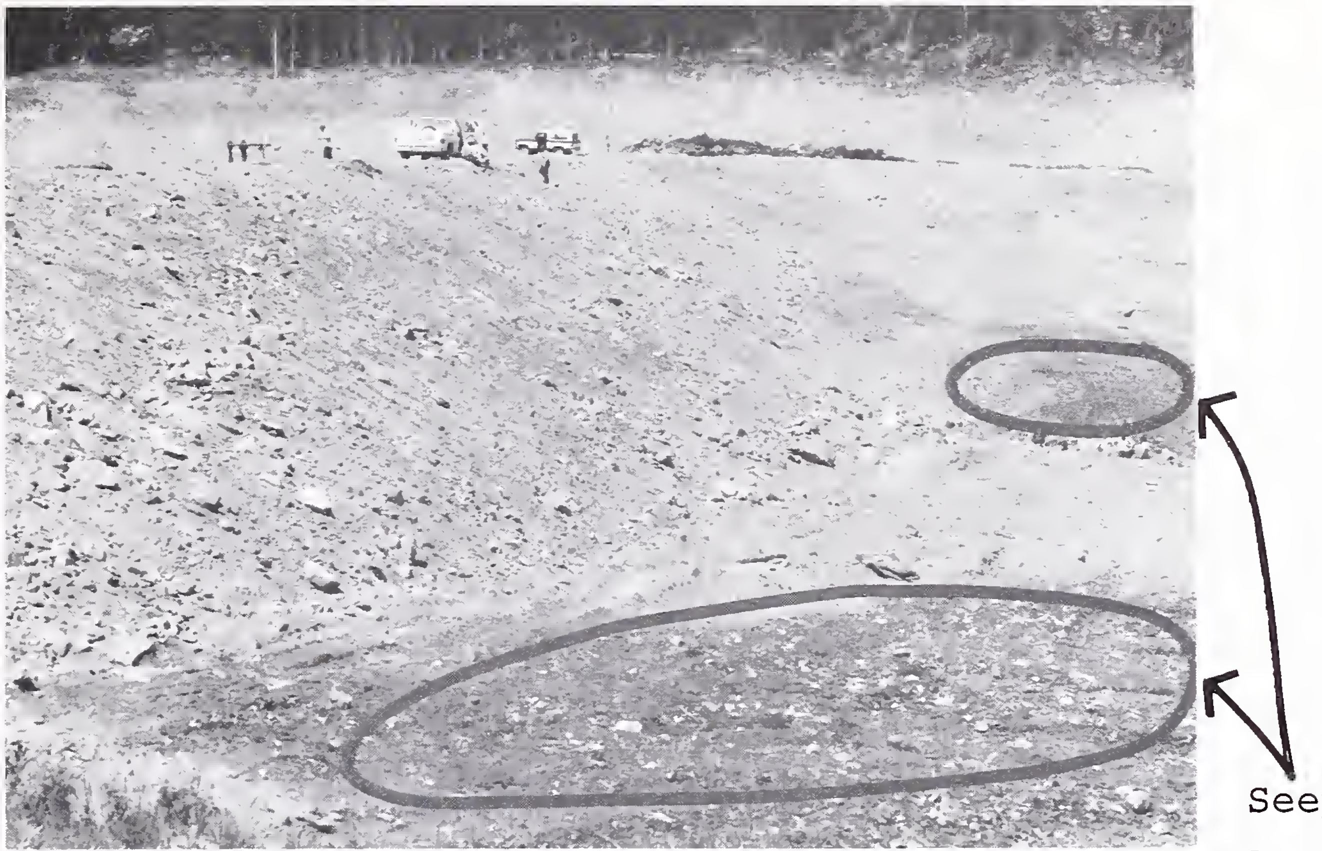
Seepage Area

PHOTO 4 Seepage Left of Low Level Conduit



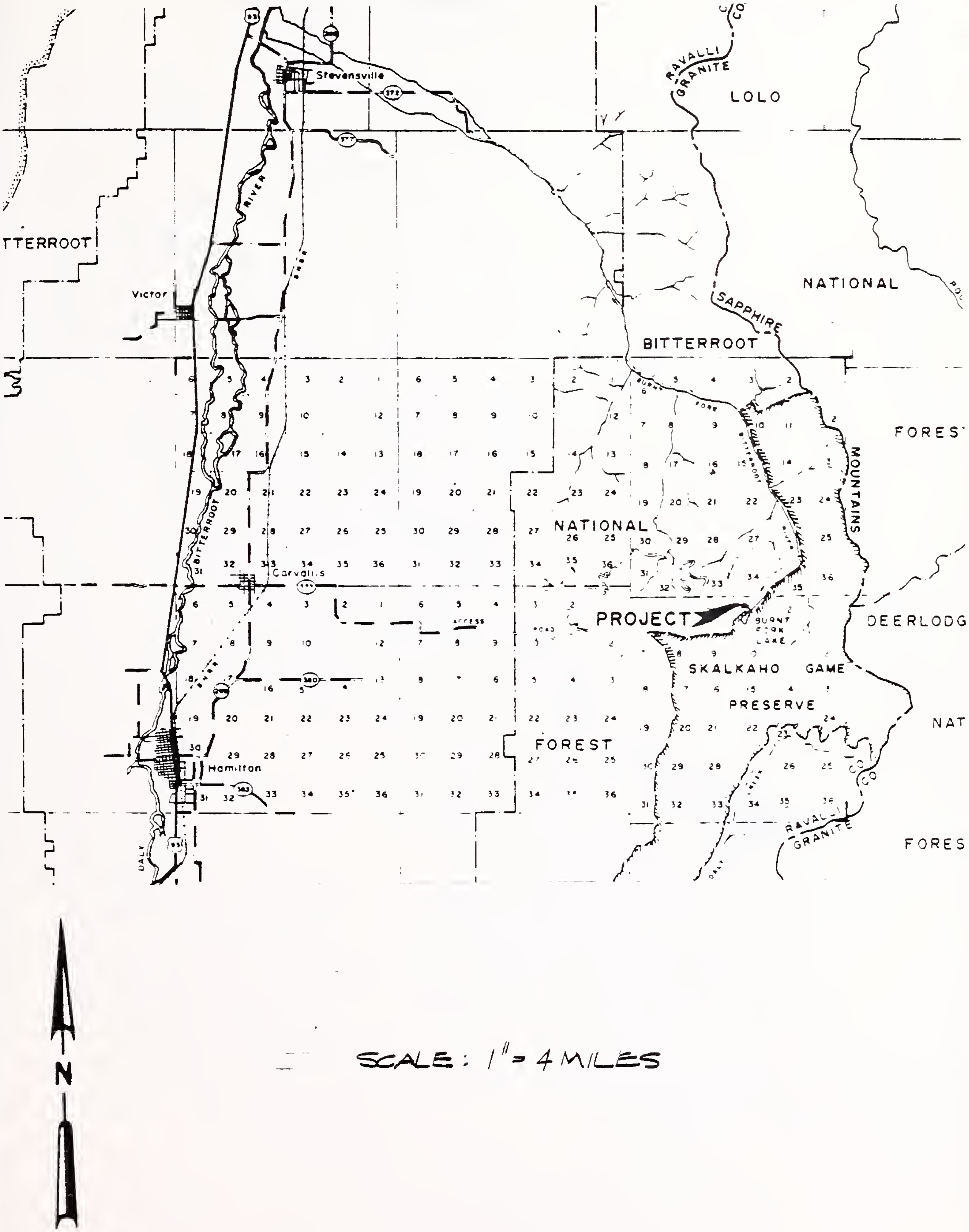
Seepage Area

PHOTO 5 Seepage Right of Low Level Conduit



Seepage
Areas

PHOTO 6 Abutment Seepage, dark areas in photo, (left and right).



SCALE: 1" = 4 MILES

PLATE 1

BURNT FORK DAM
VICINITY MAP

CH2M
HILL

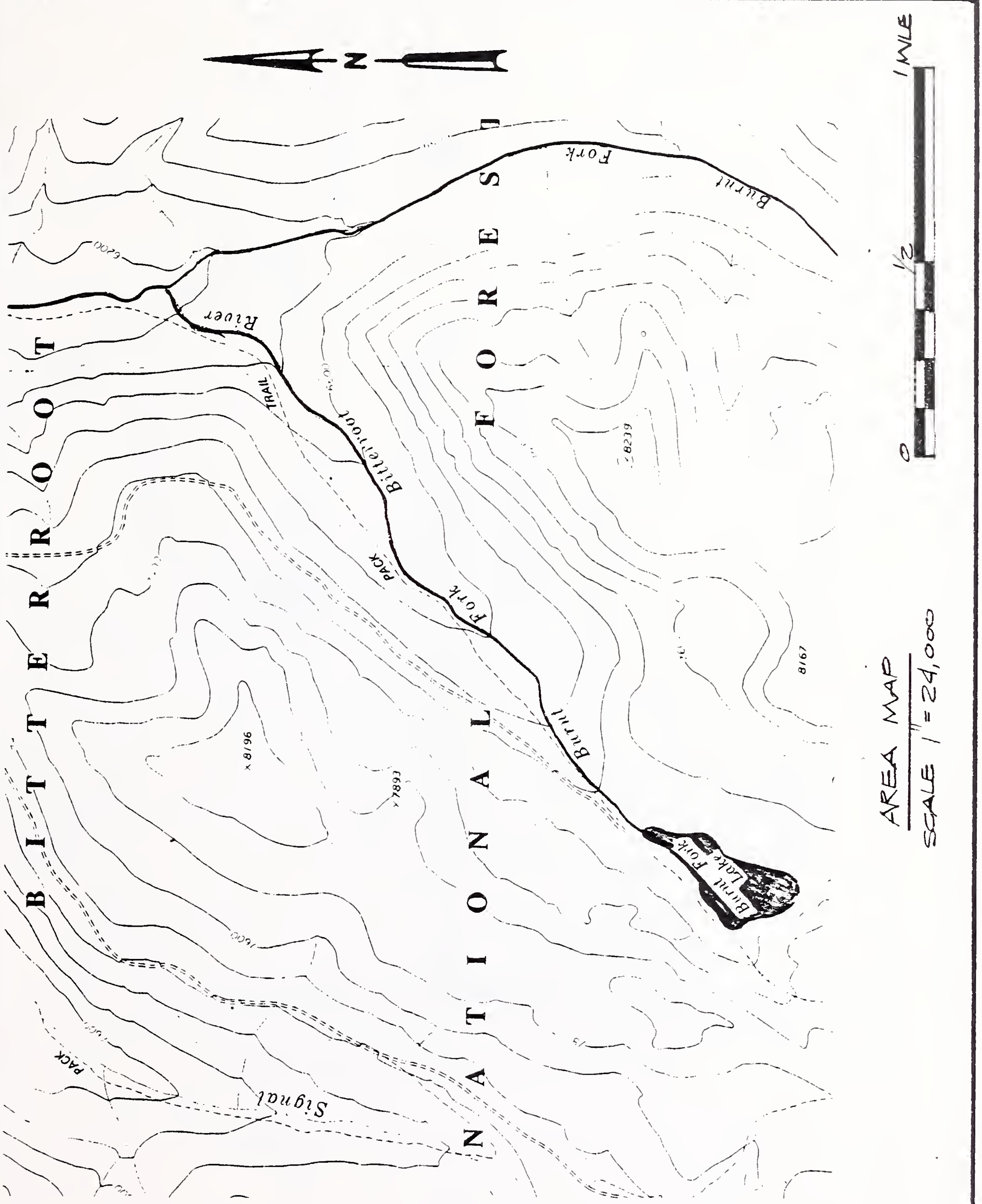


PLATE 2
BURNT FORK LAKE DAM
AREA MAP

CH2M HILL

3

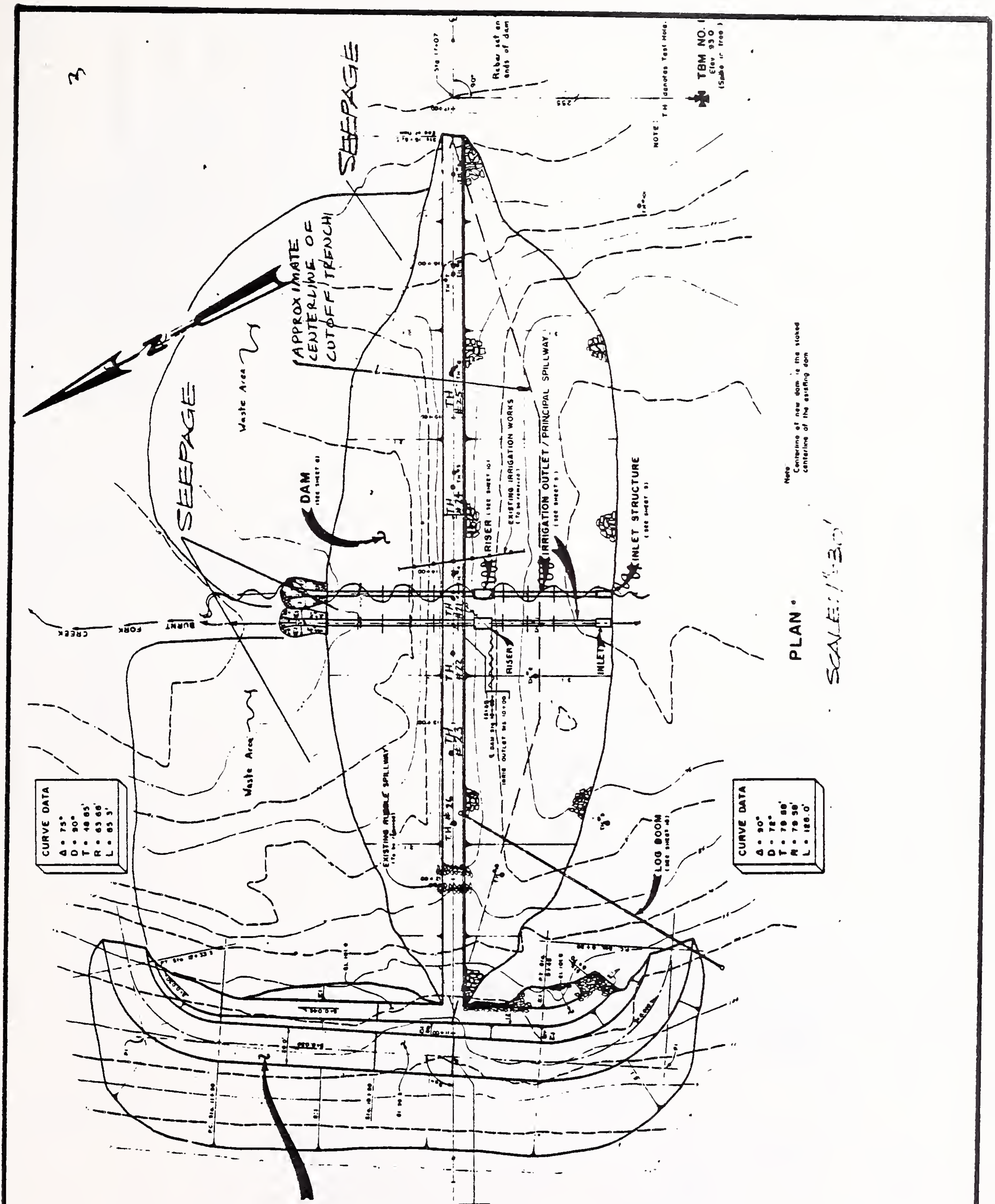
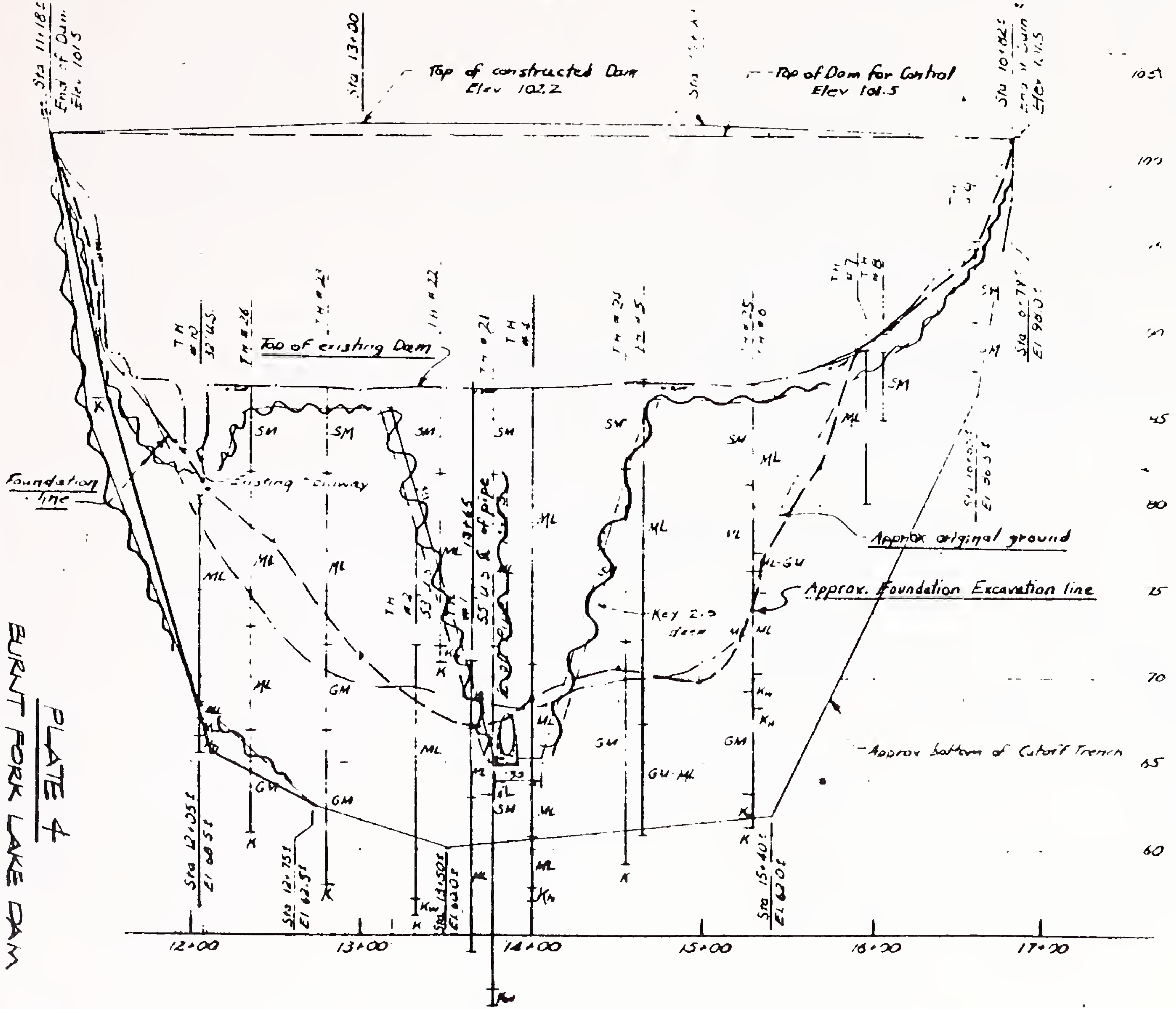


PLATE 3
BURNT FORK LAKE DAM
SITE PLAN

CH2M HILL



PROFILE ALONG ℄ CENTERLINE OF DAM

(LOOKING DOWNSTREAM)

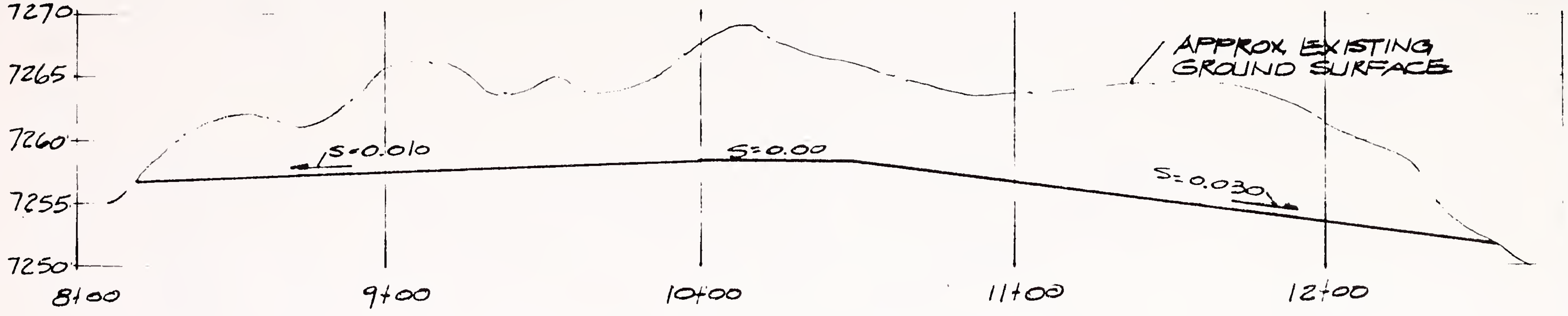
LEGEND

K = BEDROCK
Kw = WEATHERED BEDROCK
Kh = HARD BEDROCK
GM = SILTY GRAVEL; GRAVELS & SILT MIXTURES
ML = SILTS WITH VERY FINE SANDS; SANDY, CLAYEY, SILTS.
OL = ORGANIC SILTS & ORGANIC SILTY CLAYS WITH LOW PLASTICITY
SM = SILTY SAND, SANDY SILT MIXTURES

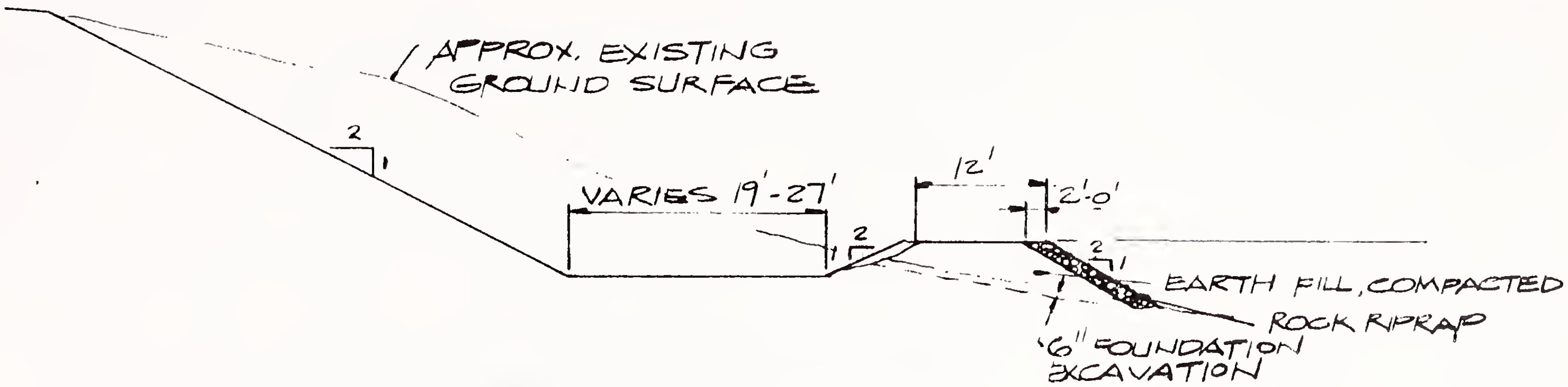
PLATE 4

BURNT FORK LAKE DAM
EMBANKMENT PROFILE & BORING LOGS

CH2M HILL



PROFILE ALONG ℄ OF EMERGENCY SPILLWAY



TYPICAL CROSS SECTION

N.T.S.

PLATE 5

BURNT FORK LAKE DAM
SPILLWAY PROFILE & SECTION

CH2M HILL

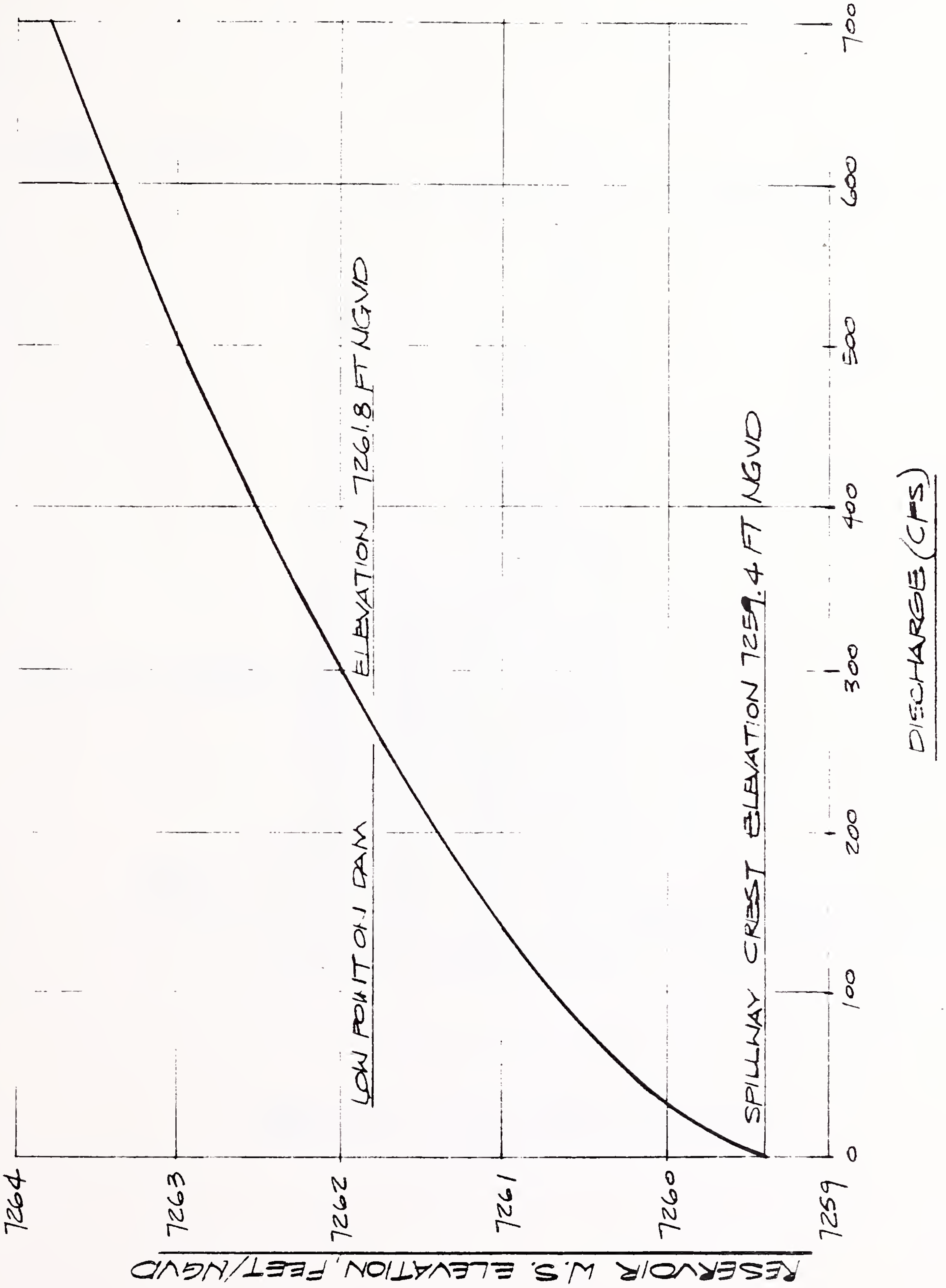
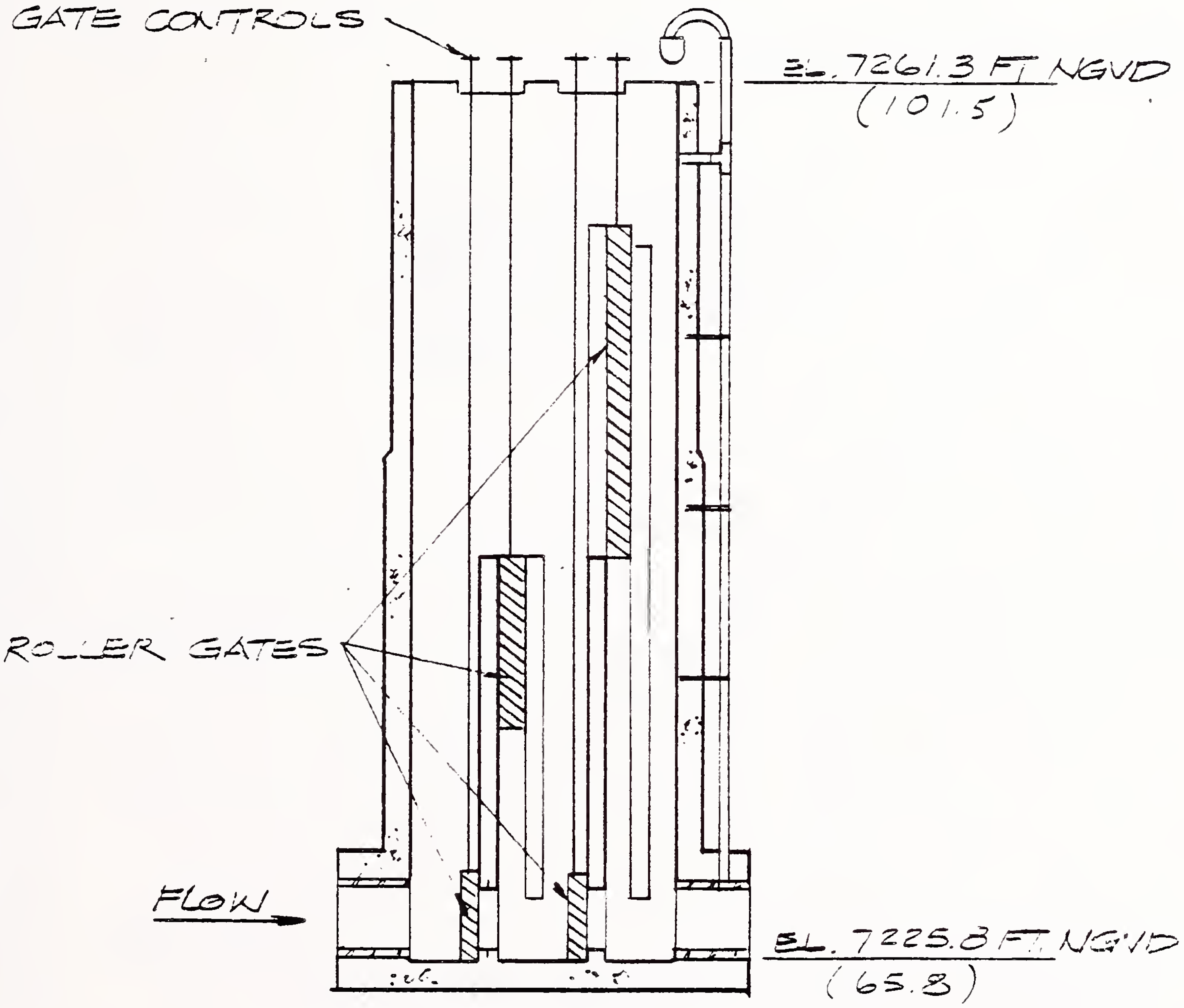


PLATE 6

BURNT FORK LAKE DAM

EMERGENCY SPILLWAY RATING CURVE

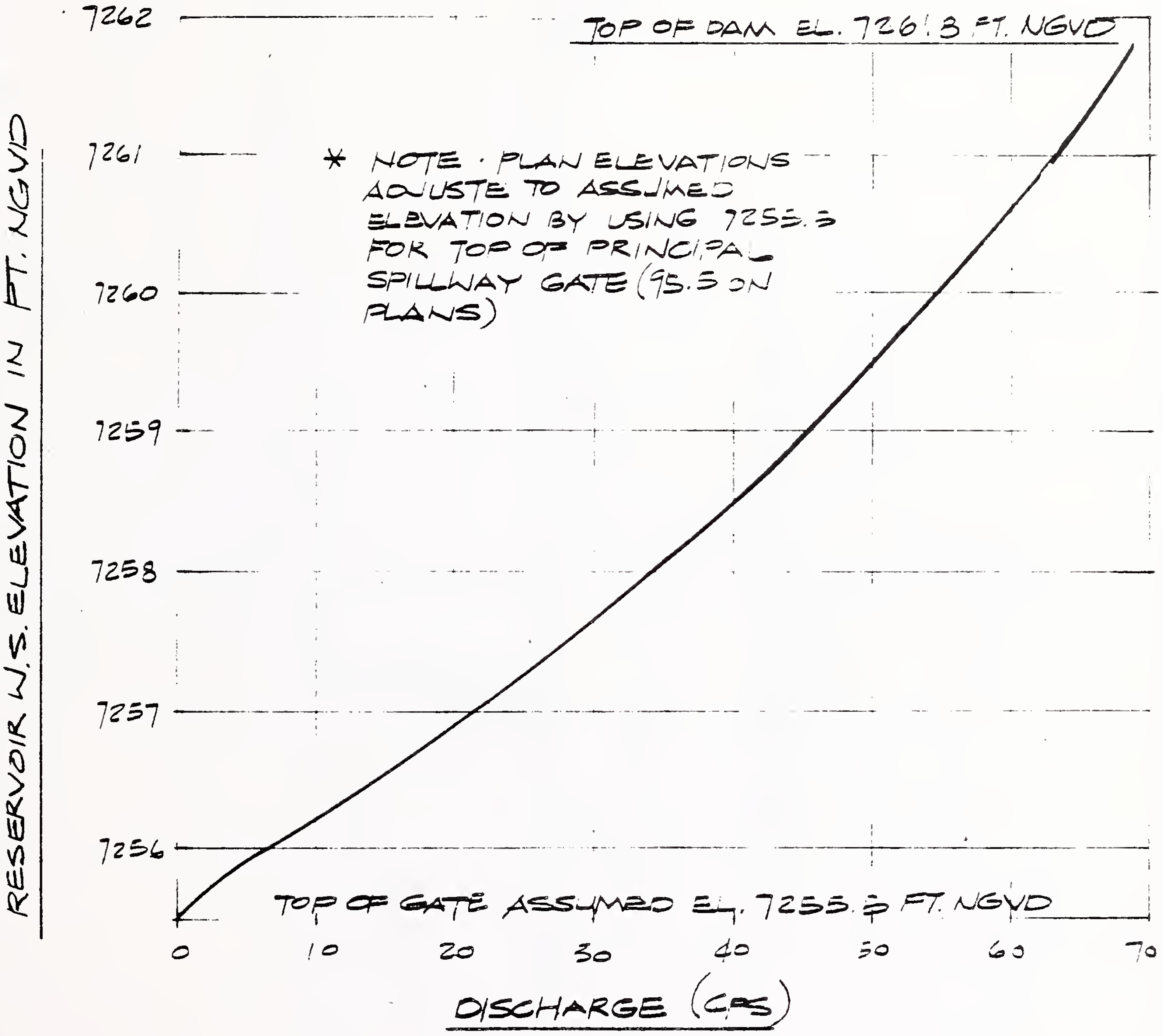
CH2M HILL



SECTION ON CENTERLINE
N.T.S.

PLATE 7
BURNT FORK LAKE DAM
OUTLET WORKS CONTROL

CH2M HILL



TOP OF DAM EL. 7261.8 FT. NGVD

* NOTE · PLAN ELEVATIONS ADJUSTE TO ASSUMED ELEVATION BY USING 7255.5 FOR TOP OF PRINCIPAL SPILLWAY GATE (95.5 ON PLANS)

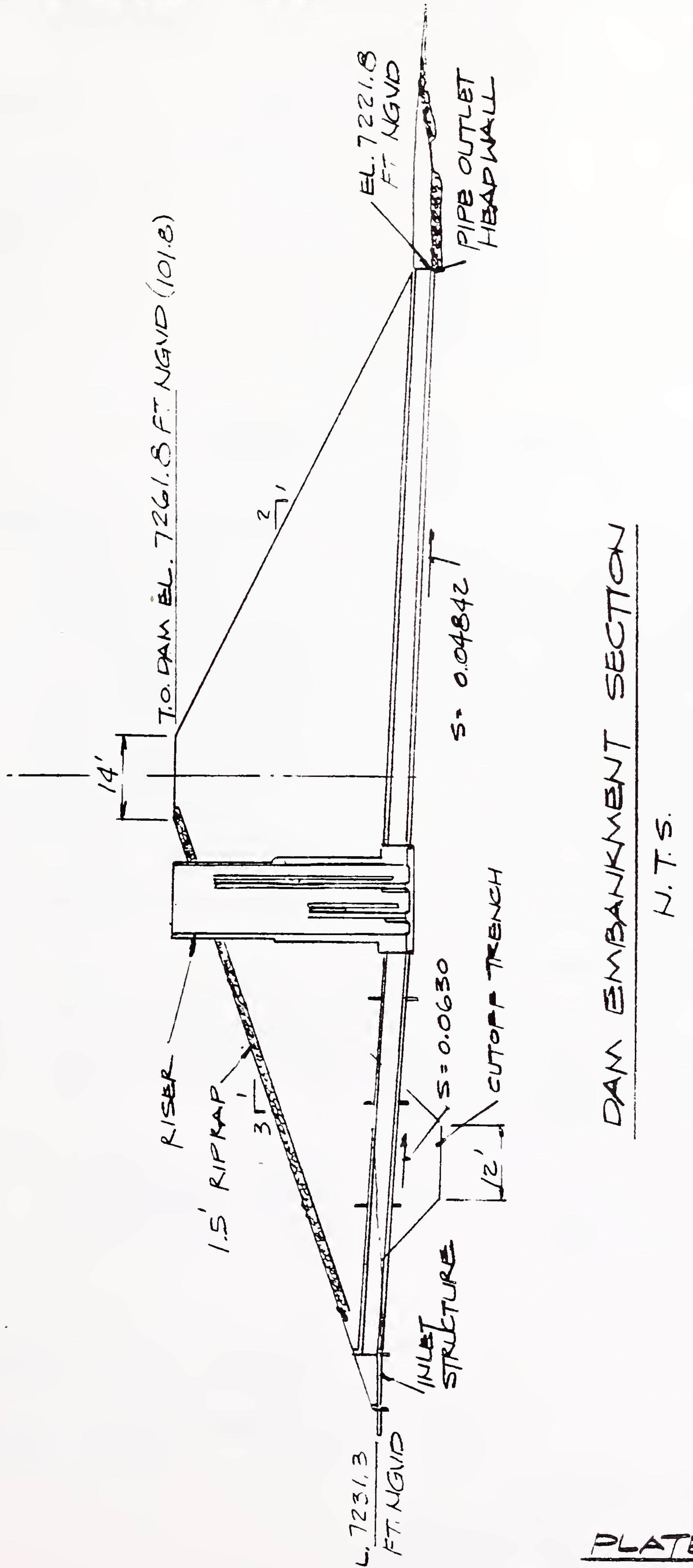
TOP OF GATE ASSUMED EL. 7255.5 FT. NGVD

(SLIDE GATES CLOSED AND ROLLER GATES ALL THE WAY UP)

PLATE 8

BURNT FORK LAKE DAM
PRINCIPAL SPILLWAY RATING CURVE

CH2M HILL

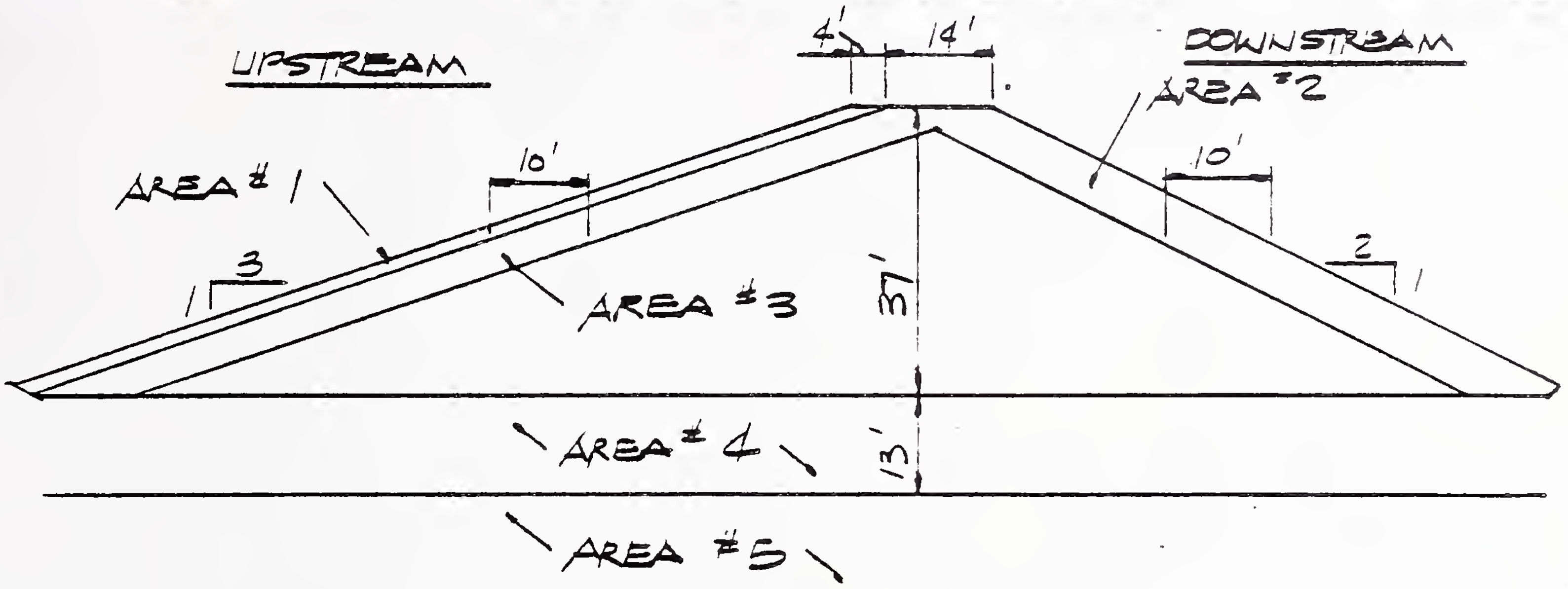


DAM EMBANKMENT SECTION

N.T.S.

PLATE 9
BURNT FORK LAKE DAM
EMBANKMENT SECTION

CH2M HILL



EMBANKMENT MODEL

N.T.S.

1. STRENGTH VALUES

AREA #	DESCRIPTION	γ_d PCF	γ_m PCF	γ_{SAT} PCF	ϕ DEGREES	C PSF
1	ROCK RIPRAP	140			42	0
2	SM & OVERSIZE		142	148	38	150
3	SM		132	139	36	150
4	FOUNDATION	115		136	35	150
5	BEDROCK		174		43	2000

2. SEISMIC LOADING

COEFFICIENT OF HORIZONTAL ACCEL. = 0.1g

3. STABILITY ANALYSIS BY S.C.S. (REF. 2)

A. ORDINARY METHOD OF SLICES
UPSTREAM FACE : F.S. = 1.3 (SUDDEN DRAWDOWN)
DOWNSTREAM FACE : F.S. = 1.3 (STEADY STATE SEEPAGE)
F.S. = 1.1 (STEADY STATE SEEPAGE WITH SEISMIC FORCES)

B. INFINITE SLOPE ANALYSIS
UPSTREAM FACE : F.S. = 4.9 (SUDDEN DRAWDOWN)
DOWNSTREAM FACE : F.S. = 2.9 (STEADY STATE SEEPAGE WITH SEISMIC FORCES)

NOTES:

1. INFORMATION TAKEN FROM REF. 2

2. EMBANKMENT SCALE ASSUMED TO BE 1" = 30'

PLATE 10
BURNT FORK LAKE DAM
EMBANKMENT STABILITY MODEL
& FACTORS OF SAFETY

CH2M HILL